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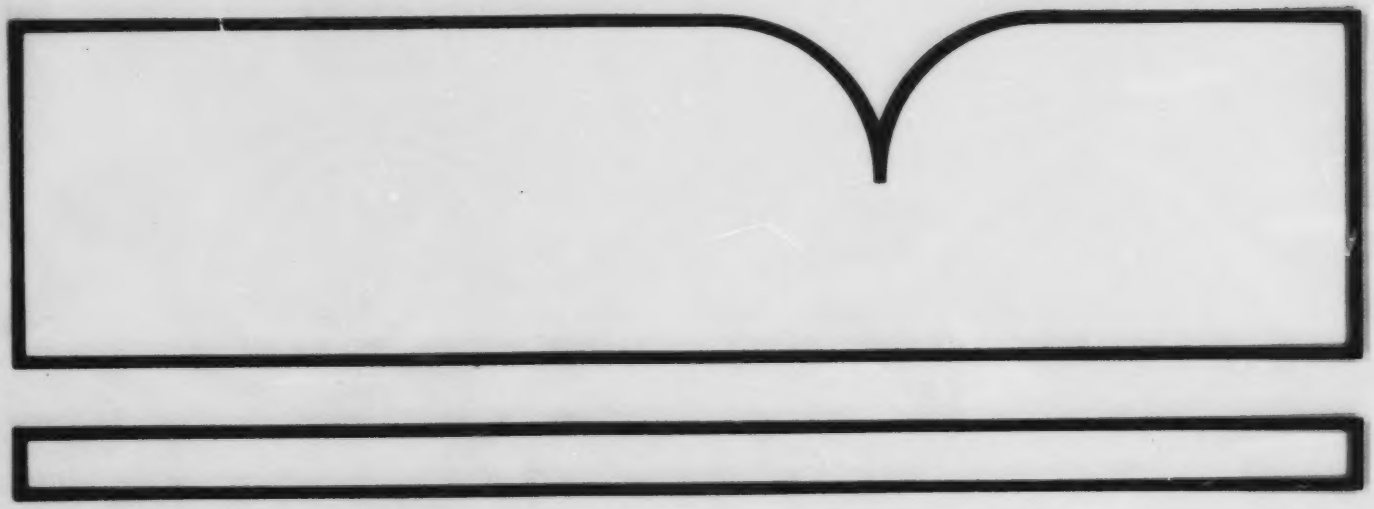
Emission Testing and Evaluation of the Enclosed Coke Pushing and Quenching System

National Steel Corp., Weirton, WV

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

May 83



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May 1983

Emission Testing and Evaluation of the Enclosed Coke Pushing and Quenching System

by

G.P. Current

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P.O. Box 431
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Contract No. 68-02-1347

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Industrial Environmental Research Laboratory
Office of Environmental Engineering and Technology
Research Triangle Park, NC 27711

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16. ABSTRACT The report describes a coke battery, placed into operation in May 1973 by National Steel's Weirton Steel Division, Weirton, WV. Consisting of 87 ovens, each 6 m tall, the battery includes features to reduce environmental discharges from the coke pushing and quenching operations. Pushing emissions were to be contained by a one-spot coke receiver car and retractable coke guide hood evacuated through a fan/scrubber system on the traction drive car. The hot coke would then be discharged from the receiver car into below-track hoppers from which it was withdrawn and quenched semicontinuously in vibrating conveyors. From the outset, system operability was severely reduced by erosion, corrosion, and oxidation of coke handling components and the presence of explosive gas mixtures, especially in the quenching facilities. Extensive efforts were made to resolve these problems. The quench system is now shut down; alternative facilities are being explored. Emissions measurements in the pushing control scrubber exhaust averaged 224 mg/N cu m (18 g/Mg coke). Operating costs were estimated to be 26 and 280% higher than for conventional uncontrolled pushing and baffled quenching.

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a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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Coke	Stationary Sources	21D
Coking	Coke Pushing	13H
Quenching (Cooling)		
Tests		14B
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Abstract

A new coke battery was placed into operation in May 1973 by Weirton Steel Div., National Steel Corporation. Comprised of 87 six-meter ovens, this battery included in its design features to reduce environmental discharges from the coke pushing and quenching operations. Pushing emissions were to be contained by a one spot coke receiver car and retractable coke guide hood evacuated through a fan-scrubber system installed on the traction drive car. The hot coke would then be discharged from the receiver car into below track hoppers from which it was withdrawn and quenched semi-continuously in vibrating conveyors. From the outset, operability of the system was severely reduced by errosion, corrosion, and oxidation of coke handling components and the presence of explosive gas mixtures, especially in the quenching facilities. Extensive efforts were made to resolve these problems. The quench system is currently shut down; alternative facilities are being explored. Emission measurements in the pushing control scrubber exhaust averaged 224 mg/Nm^3 (18 g/Mg coke). Operating costs were documented to be $1.23(short)ton for the pushing system and $4.58(short)ton for the quenching system. These costs are estimated to be 26 percent and 280 percent, respectively, higher than for conventional uncontrolled coke pushing and baffled quench tower installations.

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SECTION I

INTRODUCTION

In May of 1973, Weirton Steel Division, National Steel Corporation, completed the construction of a new coke plant on Brown's Island which is located at Mile Point 62 on the Ohio River near Weirton, West Virginia. The coke battery is comprised of 87 six-meter ovens with a design coke production rate of approximately 2900 metric tons per day (3200 short tons per day). This coke plant features highly advanced production and environmental control facilities. One very significant feature of the coke plant involved the development of new technology for the control of emissions from the coke pushing and quenching operations. In 1972 Weirton Steel Division of National Steel Corporation entered into the first of two jointly funded research and development contracts with the Environmental Protection Agency for the development of an enclosed coke pushing and quenching system. This technology, designed and constructed by Weirton Steel Division, National Steel Corporation, and Koppers Company with the support and cooperation of the Environmental Protection Agency, provides for the total enclosure of the coke during the pushing, transfer and quenching operations. Scrubbers and mist eliminators are utilized to minimize the particulate emissions from these operations.

Contract No. 68-02-0622, executed in early 1972,entailed the design and construction of this system. This contract was concluded in September 1973, with the issuance of the "Enclosed Coke Pushing and Quenching System Design Manual"[1].

Contract No. 68-02-1347 titled "Emission Testing and Evaluation of the Enclosed Coke Pushing and Quenching System" was executed in June 1973. The purpose of this contract was to document the system's emission control capability, reliability, and operating cost over a twelve-month period of performance.

Unfortunately there have been numerous problems that have prevented the continuous operation of this system. These problems have necessitated the complete re-design and replacement of many major components within the system and have resulted in lengthy delays during which time the system was inoperative. Programs, costimg several million dollars, have been implemented to improve the operability of the system during the period from 1973 through 1980. Although significant progress has been made in this regard, continuous operation has still not been achieved at the time of this writing due to potential explosive hazards associated with the system.

This report was submitted to the Environmental Protection Agency in fulfillment of Contract No. 68-02-1347. It documents the design of the system after the completion of the multi-million dollar optimization programs and describes the problems which were encountered. In addition, an analysis of the environmental, energy and economic aspects of the system is presented. This work was completed as of December 1980.

SECTION II

CONCLUSIONS

The enclosed coke pushing and quenching system demonstration should be considered as a full scale research and development program. Although the program is not considered totally successful, the technological benefits derived by others from this demonstration cannot be over-emphasized. As a forerunner in the development of enclosed coke pushing and quenching technology in the United States, this program has influenced subsequent designs by others who profitted from the early successes and failures at Weirton Steel Division.

The enclosed pushing emissions control system is a viable technology which has the ability to comply with reasonably available control technology (RACT) and proposed lowest available emission rate (LAER) standards applicable to the Brown's Island Plant. The maintenance requirements associated with this mobile system are significant, but acceptable. The operating cost for this mobile system is estimated to be $1.35 per metric ton ($1.23 per short ton), which is approximately 26 percent higher than a conventional uncontrolled system. Further modifications are required to eliminate the potential explosive hazard associated with the gas cleaning car. This may be best accomplished via the expansion of gas cleaning car fan capacity and improvements to the battery refractory and heating systems to minimize under-carbonized coke. A major disadvantage to this mobile system is its present reliance on a refractory lined transfer car which dictates the utilization of the underground continuous quenching system.

Consideration is presently being given to the replacement of the refractory lined transfer car with a quench car that is compatable with the aboveground quenching facilities.

The anticipated advantage of the underground continuous quenching system was the opportunity for improved control of coke moisture and steam emissions during the quenching operation. Improved control of coke moisture was not achieved by this installation, and in the opinion of National Steel Corporation, the control of steam emissions became an academic point since, given clean water for quenching, adequate control can be achieved by the installation of mist suppressors in conventional quench towers. The operating cost for the underground quencher is estimated to be $5.05 per metric ton ($4.58 per short ton) which is an increase of 280 percent above the operating cost of a conventional quench tower. This cost is excessive, and any benefits derived from this sophisticated technology do not justify this increase. The operating experience at Weirton cannot lead to the recommendation that this technology be installed elsewhere, and the Company is presently giving consideration to the replacement of the underground quencher with an aboveground quenching tower.

The enclosed coke pushing and quenching system demonstration exemplifies the fact that, in many cases, the installation of highly sophisticated technology in an attempt to achieve the ultimate control is not in the best interests of the environment. A pollution control technology with the capability of high operability and reliability at an adequate particulate removal efficiency is more environmentally effective than the technology that operates at low operability and reliability, but with an ultra high particulate removal efficiency. The Company is dedicating future efforts in the develoment of lower cost technology which can achieve

adequate emission control and demonstrate the high degree of reliability required for continuous operation. One technology under development at the Weirton Plant is the Two-Step Quenching (T.S.Q.) System for pushing emissions control.

SECTION III

DESCRIPTION OF THE ENCLOSED COKE PUSHING AND QUENCHING SYSTEM

The Weirton Steel Division Enclosed Coke Pushing and Quenching System is a totally integrated facility designed to capture and clean the gaseous and particulate emissions normally discharged during the pushing and quenching operations. Figure 1 is a perspective arrangement of the facilities with an alphabetical legend referencing the following system components:

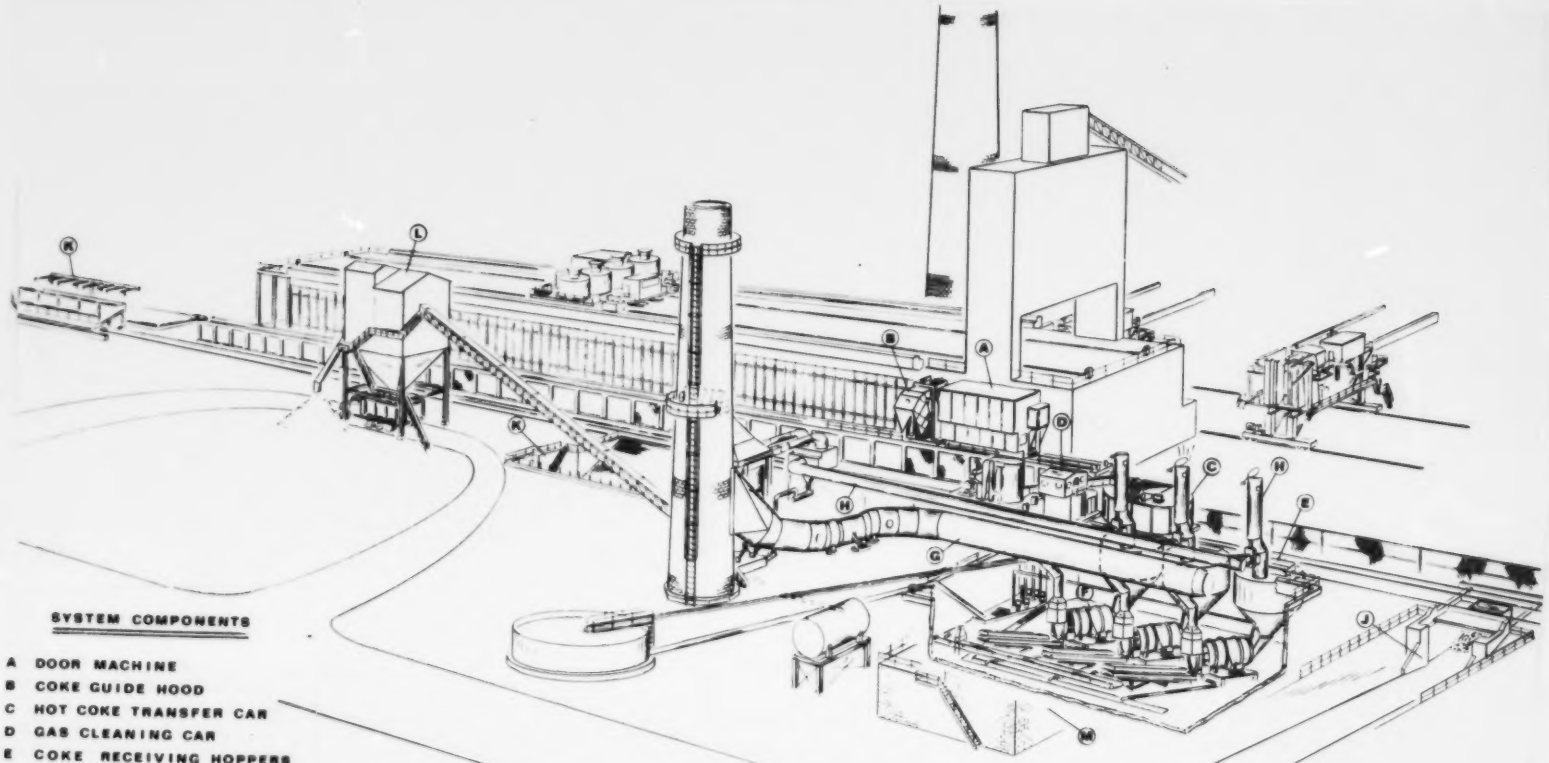
1. A standard door machine with an enclosed coke guide hood that mates with both the oven door frame and the transfer car (References A and B).

2. A closed, one spot, refractory lined hot coke transfer car which accepts the hot coke and is exhausted through a gas cleaning system to control emissions (Reference C).

3. A gas cleaning car which minimizes pushing and transfer emissions while also serving as the locomotive for the transfer car (Reference D).

4. Three underground refractory lined hoppers which receive the hot coke from the transfer car (Reference E).

5. A coke hopper fume exhaust and gas cleaning system to minimize emissions during the discharge of hot coke from the transfer car to the underground hoppers (Reference H).



SYSTEM COMPONENTS

- A DOOR MACHINE
- B COKE GUIDE HOOD
- C HOT COKE TRANSFER CAR
- D GAS CLEANING CAR
- E COKE RECEIVING HOPPERS
- F COKE QUENCHING DRUM
- G EXHAUST STEAM MAIN
- H COKE HOPPER FUME EXHAUST AND GAS CLEANING SYSTEM
- J EMERGENCY COKE DUMP PIT
- K EMERGENCY COKE QUENCHING SYSTEM AND WHARF
- L COKE HANDLING
- M CONTROL ROOM

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12-4-80

Figure 1

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
PERSPECTIVE ARRANGEMENT

DRAWN BY M CLELLAND | DATE OCT 1-72 | SCALE | 319-A600

6. Three underground rotary drums to quench the hot coke from the respective underground hoppers (Reference F).

7. An exhaust system with mist eliminator facilities to remove and clean the steam emissions from the rotary drums (Reference G).

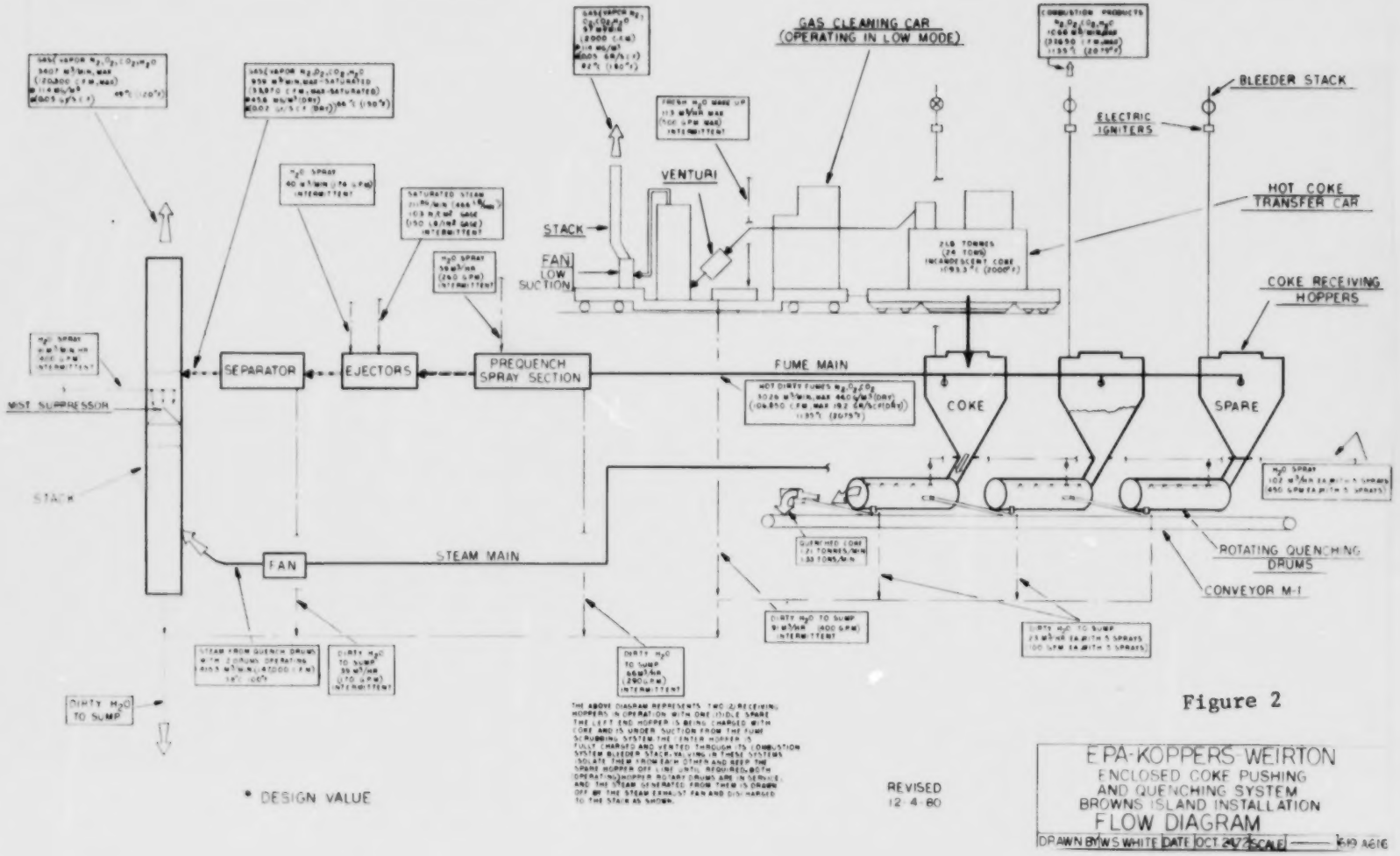
8. An emergency coke dump pit to quench hot coke which has been accepted in the transfer car but cannot be accepted by the rotary drum quenchers (Reference J).

9. An emergency coke quenching system and wharf to be utilized in the event that the total enclosed coke pushing and quenching system is inoperative (Reference K).

10. A coke handling system consisting of conveyor belt facilities and a coke loadout bin (Reference L).

11. An electrical substation and control room which houses the necessary switch gear and centralized graphic control panel (Reference M).

The above facilities are described in further detail later in this section. Figure 2 indicates the design flow conditions within the enclosed coke pushing and quenching system with the gas cleaning car operating in the low (coke transport) mode. The performance data presented in Figure 2 represent the maximum expected flow levels for the coke hopper gas cleaning and quenching systems. The coke hopper gas cleaning system data represent the condition in which one hopper is being charged and the maximum exhaust capacity is being utilized. The quencher steam discharge data are based on the normal condition of two quenching drums operating concurrently. Figure 3 indicates the design flow conditions with the gas cleaning car operating in the high (coke pushing and



* DESIGN VALUE

THE ABOVE DIAGRAM REPRESENTS TWO (2) RECEIVING HOPPERS IN OPERATION WITH ONE (1) IDLE SPARE. THE LEFT END HOPPER IS BEING CHARGED WITH COKE AND IS UNDER SUCTION FROM THE FUME SCRUBBING SYSTEM. THE CENTER HOPPER IS FULLY CHARGED AND VENTED THROUGH ITS COMBUSTION SYSTEM BLEEDER STACK. VALVING IN THESE SYSTEMS ISOLATE THEM FROM EACH OTHER AND KEEP THE SPARE HOPPER OFF LINE UNTIL REQUIRED. BOTH OPERATING HOPPER ROTARY DRUMS ARE IN SERVICE AND THE STEAM GENERATED FROM THEM IS DRAWN OFF BY THE STEAM EXHAUST FAN AND DISCHARGED TO THE STACK AS SHOWN.

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12-4-80

Figure 2

EPA-KOPPERS WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
FLOW DIAGRAM
DRAWN BY W.S. WHITE DATE OCT 24/77 SCALE —— EPA A616

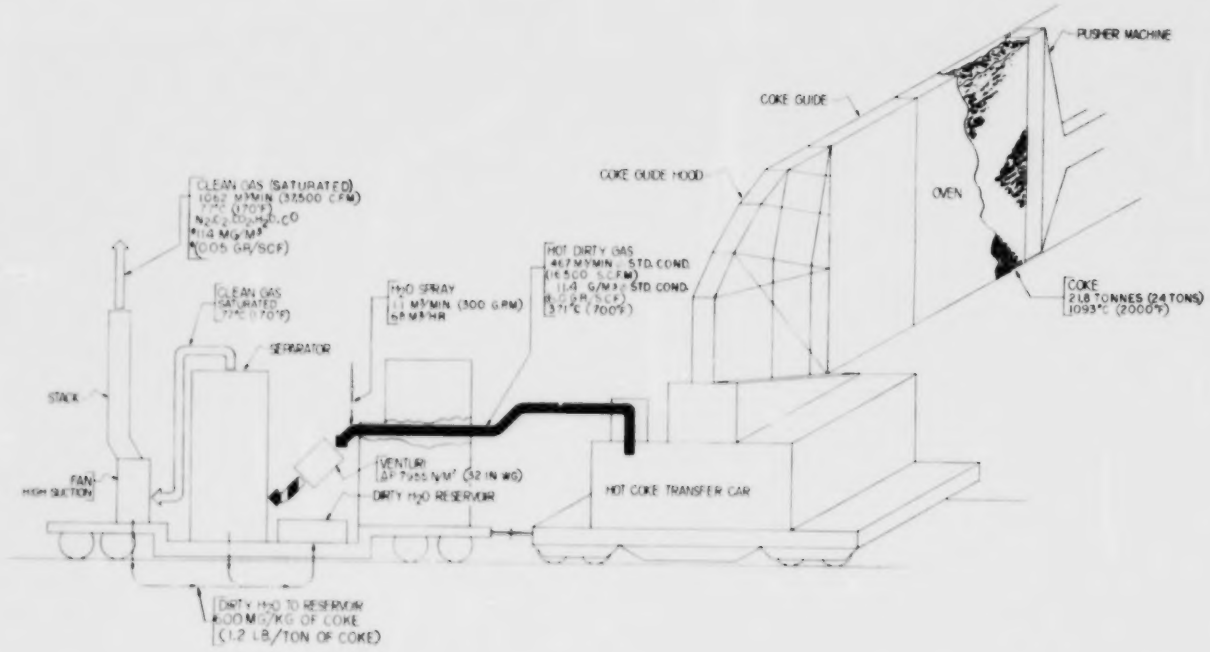

Figure 3

*DESIGN VALUE

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EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
MOBILE SYSTEM FLOW DIAGRAM DURING PUSH

DRAWN BY: J.A.S. WHITE | DATE: OCT. 24, 72 | SCALE: ——— | 339-160

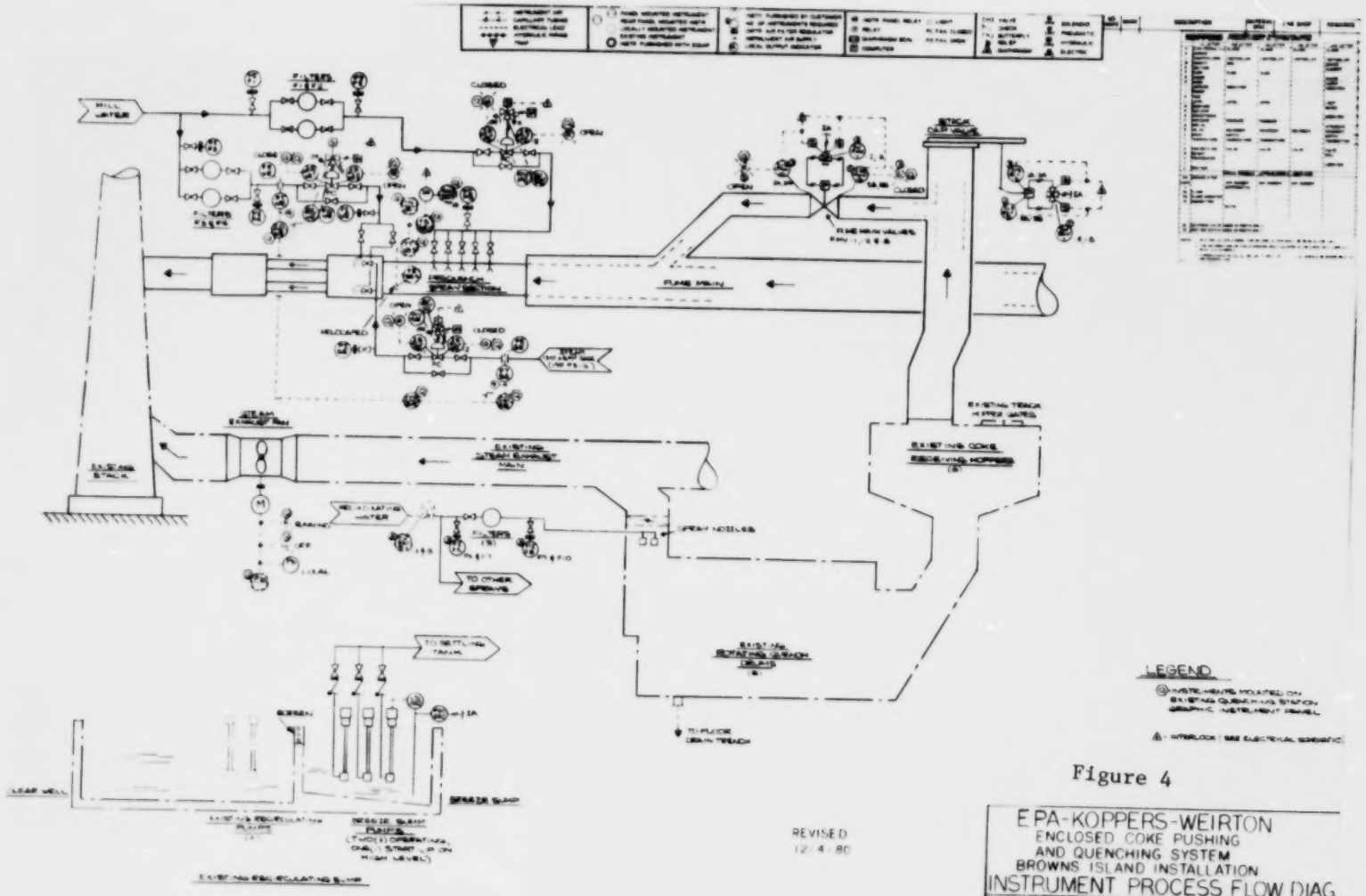
discharge) mode. A description of the low and high gas cleaning modes of the car is presented on Page 25. All gas flow and particulate loading data documented in Figures 2 and 3 are design values and are not a result of measurements. The results of the environmental testing program for the gas cleaning car are presented in Section IV-B of this report.

Figure 4 is an instrument and process flow diagram for the system with complete identification of the monitoring and control facilities. Figure 5 is a process water flow diagram which indicates the general application and use of water in the system. General service water is the source of make-up to the system and is used in a number of once through applications with subsequent discharge to the recirculation sump. Although a direct source of service water responsive to level control is available at the recirculating water sump, the major portion of the make-up requirement is provided via blowdown from the gas cleaning car scrubber, coke hopper steam-hydro gas cleaning equipment and quench stack mist eliminators. The primary use of the recirculated water is for direct spray application to quench the incandescent coke and for convevor belt protection responding to temperature monitoring.

The following paragraphs provide additional definition of the major components of the system as referenced in Figure 1.

A. Door Machine

Each door machine is of the standard design with a door extractor, door and jamb cleaners, and the necessary electrical controls for all operations, including the coke guide. The traction drive for the door machine - coke guide unit is also a part of the door machine.


LEGEND
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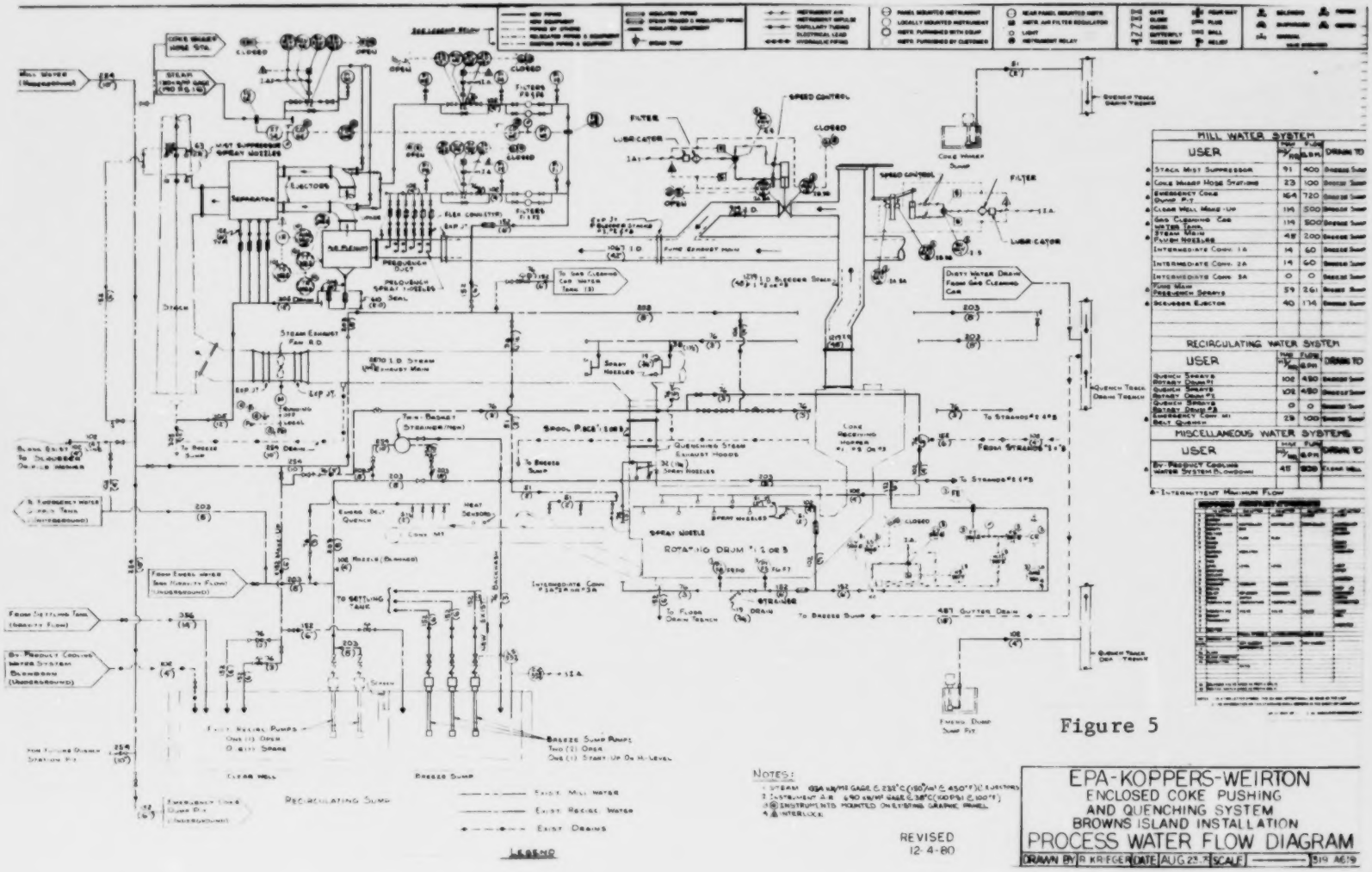
EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
INSTRUMENT PROCESS FLOW DIAG

Figure 4


MILL WATER SYSTEM
USER
Flow GPM
DRAIN TO
RECIRCULATING WATER SYSTEM
USER
Flow GPM
DRAIN TO
MISCELLANEOUS WATER SYSTEMS
USER
Flow GPM
DRAIN TO
NOTES:
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EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
PROCESS WATER FLOW DIAGRAM
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LEGEND

Figure 5

B. Coke Guide Hood (Figure 6)

The coke guide car consists of two connected sections. The first section is the coke guide rack which is similar to the standard design except that it has been totally enclosed and fits tightly against the buckstays and against the top of the jamb casting. This tight enclosure, minimizes the escape of emissions from the oven door opening or from the guide during a push.

The second section of the coke guide is the hood. It is a double segmented, quadrant type shroud with a rectangular cross section. This shroud is mounted on the front steelwork of the coke guide frame to totally enclose the push and contain the emissions during the push. The stationary section of the hood is attached to the fixed frame of the coke guide; the movable segment pivots from this frame to contact the raised section of the hot coke transfer car. Structural steel members of both segments are protected from the heat by stainless steel plates which also form the hood enclosure. These plates are loosely bolted to the structural frame. Seal plates are provided to cover the gaps between the fixed and movable sections of the hood.

After the door has been removed, the coke guide is positioned in front of the oven to be pushed by the Door Machine Operator. The guide is then racked in to give support to the coke during the push. When the hot coke transfer car has been properly spotted, the movable hood is lowered onto the raised section of the coke transfer car. This lowering action prevents the car from

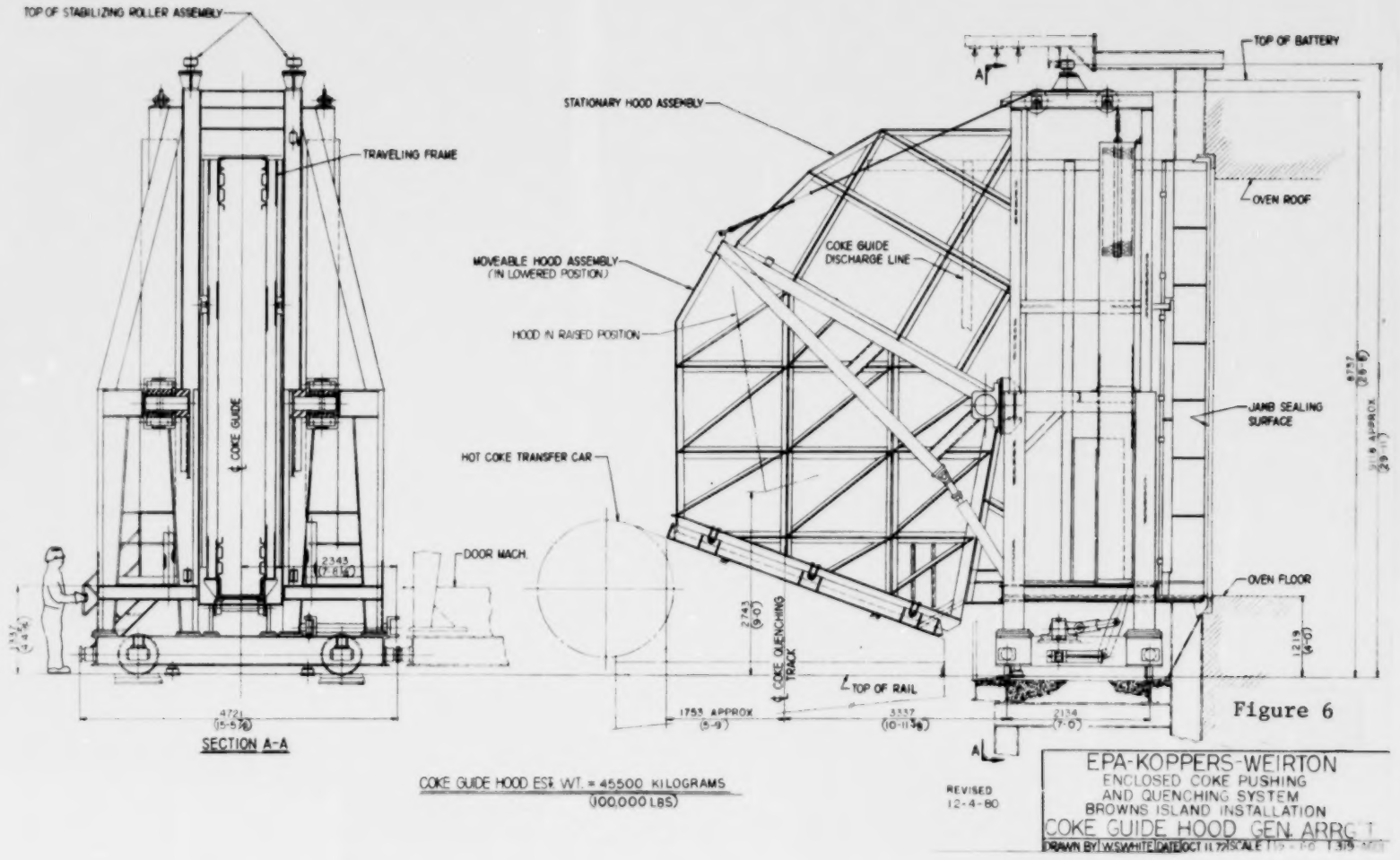

TOP OF STABILIZING ROLLER ASSEMBLY
TRAVELING FRAME
COKE GUIDE
2343 (7-8 1/4)
DOOR MACH.
HOT COKE TRANSFER CAR
4721 (15-5 7/8)
SECTION A-A
STATIONARY HOOD ASSEMBLY
MOVEABLE HOOD ASSEMBLY (IN LOWERED POSITION)
HOOD IN RAISED POSITION
COKE GUIDE DISCHARGE LINE
TOP OF BATTERY
OVEN ROOF
JAMB SEALING SURFACE
OVEN FLOOR
8737 (28-8) APPROX
7315 (24-0) APPROX
2743 (9-0)
COKE QUENCHING TRACK
TOP OF RAIL
1219 (4-0)
1753 APPROX (5-9)
3337 (10-11 3/8)
2134 (7-0)
A
A
COKE GUIDE HOOD EST. WT. = 45500 KILOGRAMS (100,000 LBS)
REVISED 12-4-80
EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
COKE GUIDE HOOD GEN. ARRGT.
DRAWN BY: W.S.WHITE DATE: OCT 11 '77 SCALE: 1/2" = 1'-0"

Figure 6

B. Coke Guide Hood (Figure 6) -(cont'd)
traveling and prevents the coke receiving car's sealing curtain from closing. The cross-battery interlock circuit is then energized permitting the push to occur.

After the pusher ram has been retracted, the Door Machine Operator raises the fume hood and the traction drive interlock for the hot coke transfer car is released.

C. Hot Coke Transfer Car (Figure 7)
The hot coke transfer car is a four-axle type car with a fabricated structural steel frame supporting one large hopper which is capable of handling one oven of coke in a single position. The hopper is totally enclosed including a sealable opening which is raised and canted toward the oven to meet the extendable hood segment of the coke guide. Also, there is a flexible stainless steel retractable sealing curtain which closes over the opening during the travel period. This curtain is driven by pushbutton from the cab of the gas cleaning car.

The one-spot enclosed coke hopper is constructed of carbon steel with an internal lining of high duty refractory fire brick. Hinged hopper gates for the discharge opening in the bottom of the hopper are pneumatically operated from the gas cleaning car cab. When the gates are opened, the car cannot travel. The gates open downward and out to provide a nearly total enclosure with the top of the individual track hopper.

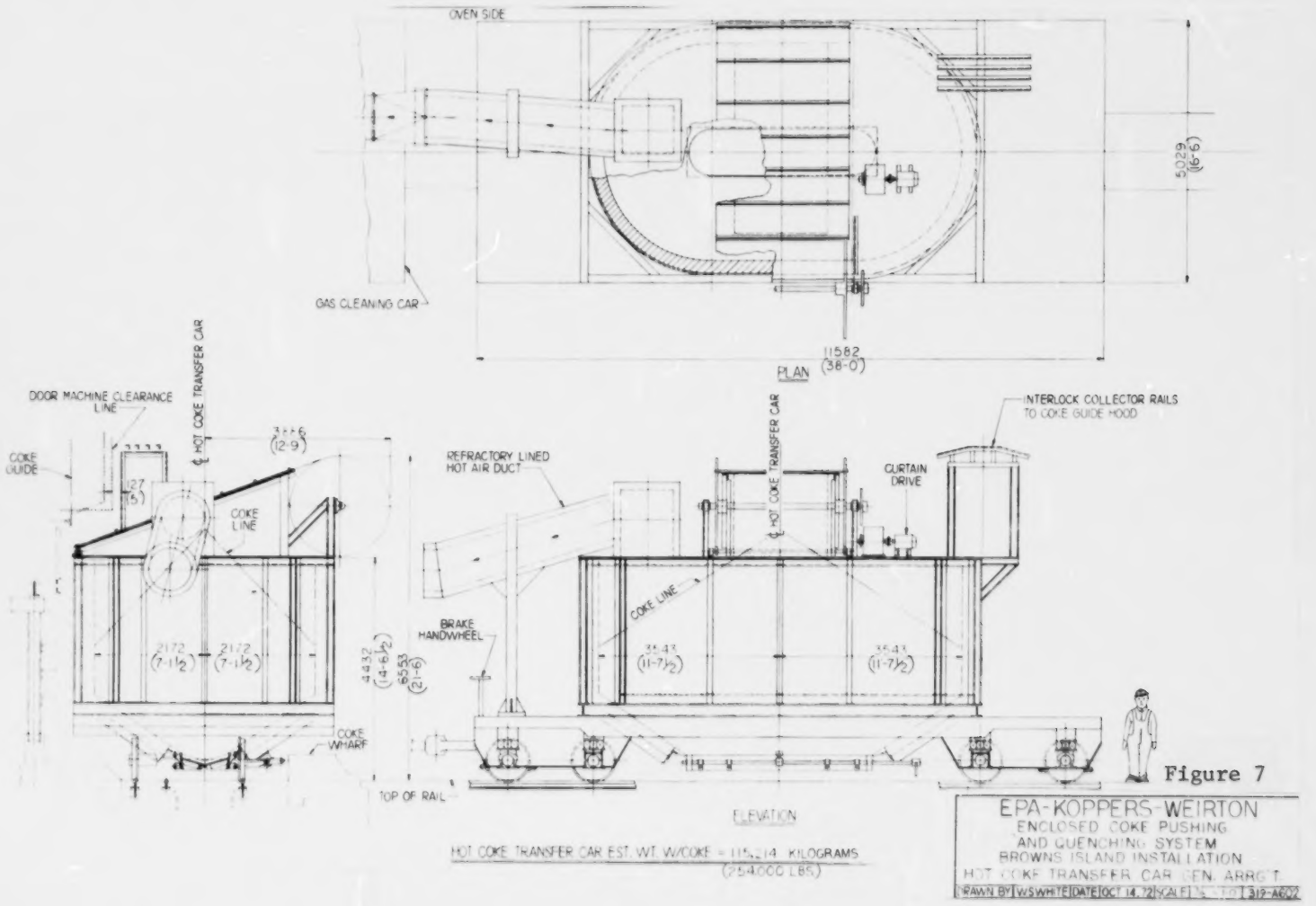

OVEN SIDE
GAS CLEANING CAR
5029 (16-6)
11582 (38-0)
PLAN
DOOR MACHINE CLEARANCE LINE
HOT COKE TRANSFER CAR
COKE GUIDE
3966 (12-9)
127 (5)
COKE LINE
2172 (7-1½)
2172 (7-1½)
4432 (14-6½)
6553 (21-6)
COKE WHARF
TOP OF RAIL
REFRACTORY LINED HOT AIR DUCT
HOT COKE TRANSFER CAR
INTERLOCK COLLECTOR RAILS TO COKE GUIDE HOOD
CURTAIN DRIVE
BRAKE HANDWHEEL
COKE LINE
3543 (11-7½)
3543 (11-7½)
ELEVATION
HOT COKE TRANSFER CAR EST. WT. W/COKE = 115214 KILOGRAMS (254000 LBS)
EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
HOT COKE TRANSFER CAR GEN. ARRGT
DRAWN BY W.S.WHITE DATE OCT 14, 72 SCALE 1/8" = 1'-0" 319-A602

Figure 7

C. Hot Coke Transfer Car (Figure 7) (cont'd)

To position the hot coke transfer car at the oven, the Operator moves to an approximate location where lights will indicate whether the transfer car is either right or left of the receiving position. The Operator then moves the transfer car as needed to complete this pushing interlock where a third light indicates that the car is centered. Once the car is spotted the sealing curtain is opened and the coke guide is lowered.

D. Gas Cleaning Car (Figure 8)

The gas cleaning car is composed of two sections: the Operator's cab and locomotive and the gas cleaning system. From the Operator's cab the Operator can move the gas cleaning car and the hot coke transfer car unit, and control the transfer car curtain, dump gates, and the gas cleaning equipment.

The scrubbing system, which is mounted on the gas cleaning car, consists of spray nozzles for cooling the hot gases in the duct from the hot coke transfer car and a high energy variable throat venturi scrubber. The gas passes through the high energy venturi scrubber, the flooded elbow, the cyclonic separator, and finally through the fan and out the exhaust stack. Contaminated water from the scrubbing system is returned to the main recirculating water sump and is periodically replenished from a fixed source by the car Operator.

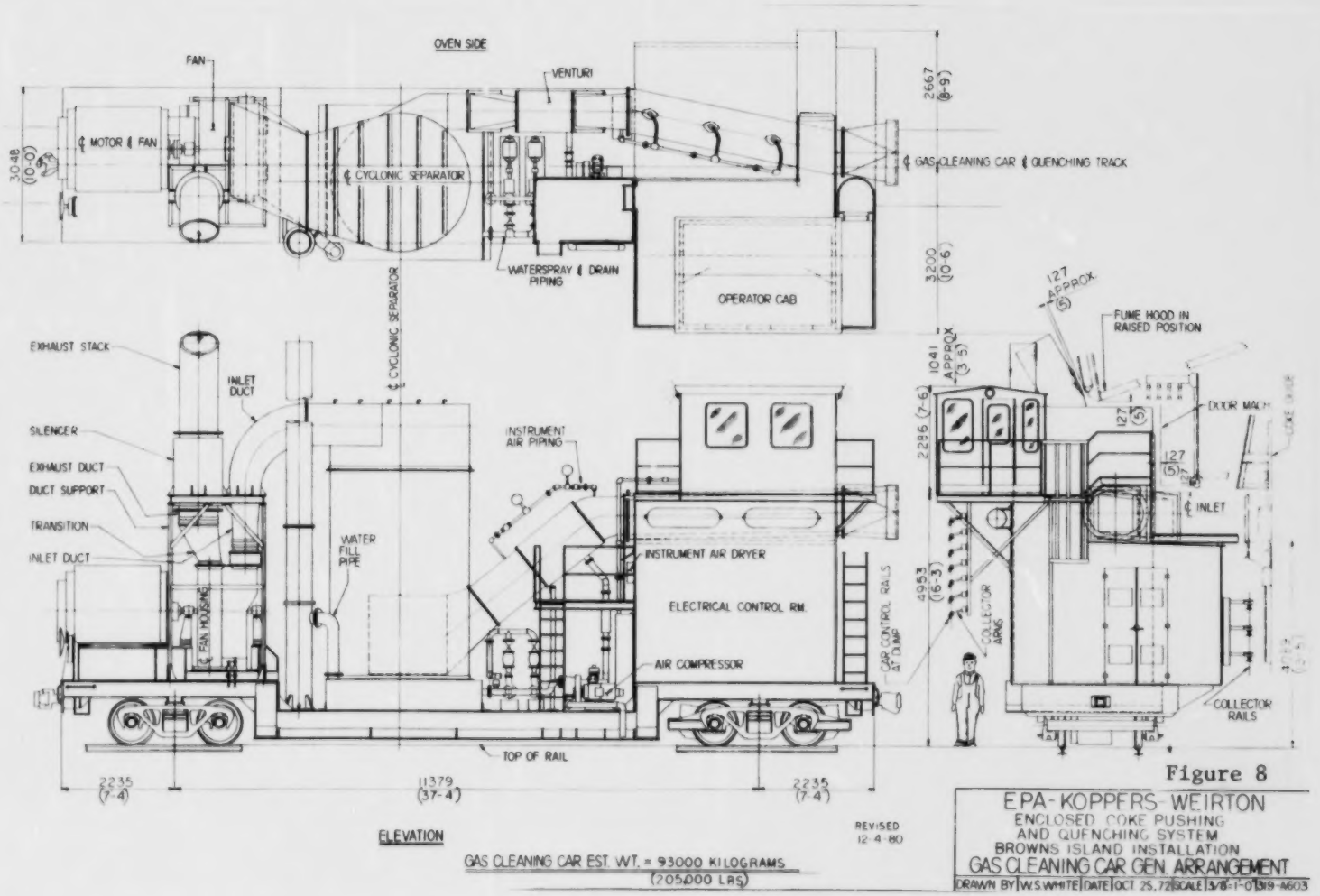


Figure 8

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
GAS CLEANING CAR GEN. ARRANGEMENT

DRAWN BY W.S.WHITE | DATE OCT 25, 72 | SCALE 3/8-1-0 | 319-A603

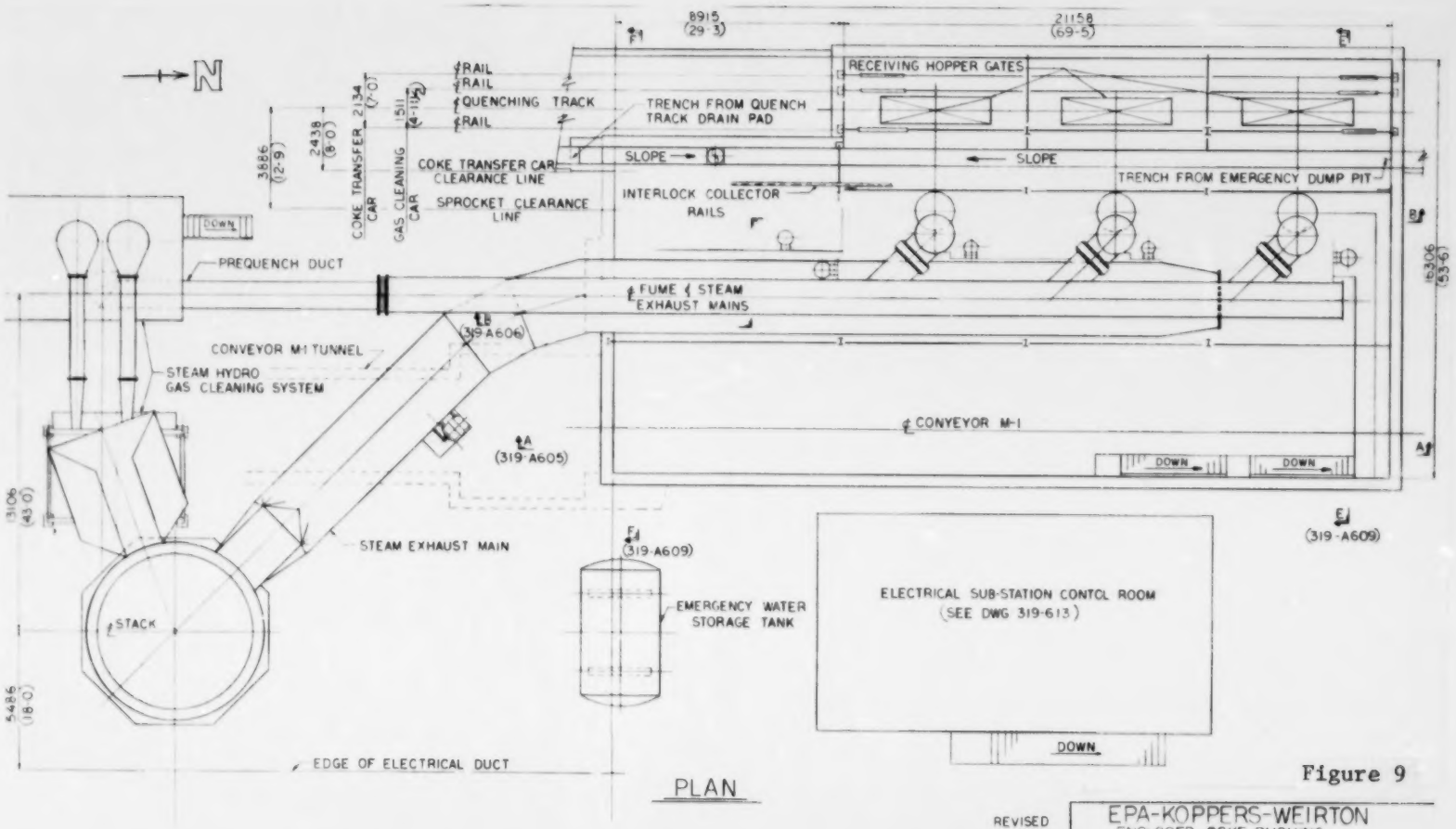
D. Gas Cleaning Car (Figure 8) (cont'd)

The suction fan is equipped with a two-position inlet louver control and the venturi throat is automatically operated to two positions. Both of these operations are pneumatically controlled. This provides two modes of gas cleaning operation. During start-up and during the coke transport period the venturi is in a full open position and the fan inlet louvers are restricted. The drop across the venturi in this mode should be 2486 N/m^2 (10 in. W.C.) or less. While in the coke receiving and discharge operations, the venturi is moved to its most restrictive position and the fan inlet is full open. A pressure drop across the venturi of approximately 7955 N/m^2 (32 in. W.C.) is expected during this mode.

The referenced drawing indicates clearances between the gas cleaning car and coke guide hood and door machine that are far more critical than any imposed by the use of the conventional quenching equipment. Track alignment becomes critical under these new conditions and of necessity tracks must be supported on firm and predictable foundations. Maintenance attention will be required to assure track and car conditions consistent with these clearances.

E. Coke Receiving Hoppers (Figures 9 through 14)

Three coke receiving hoppers are located at the quenching station beneath the quenching track for receiving incandescent coke from the hot coke transfer car. Each of the three hoppers can hold one oven of coke. Under normal operating



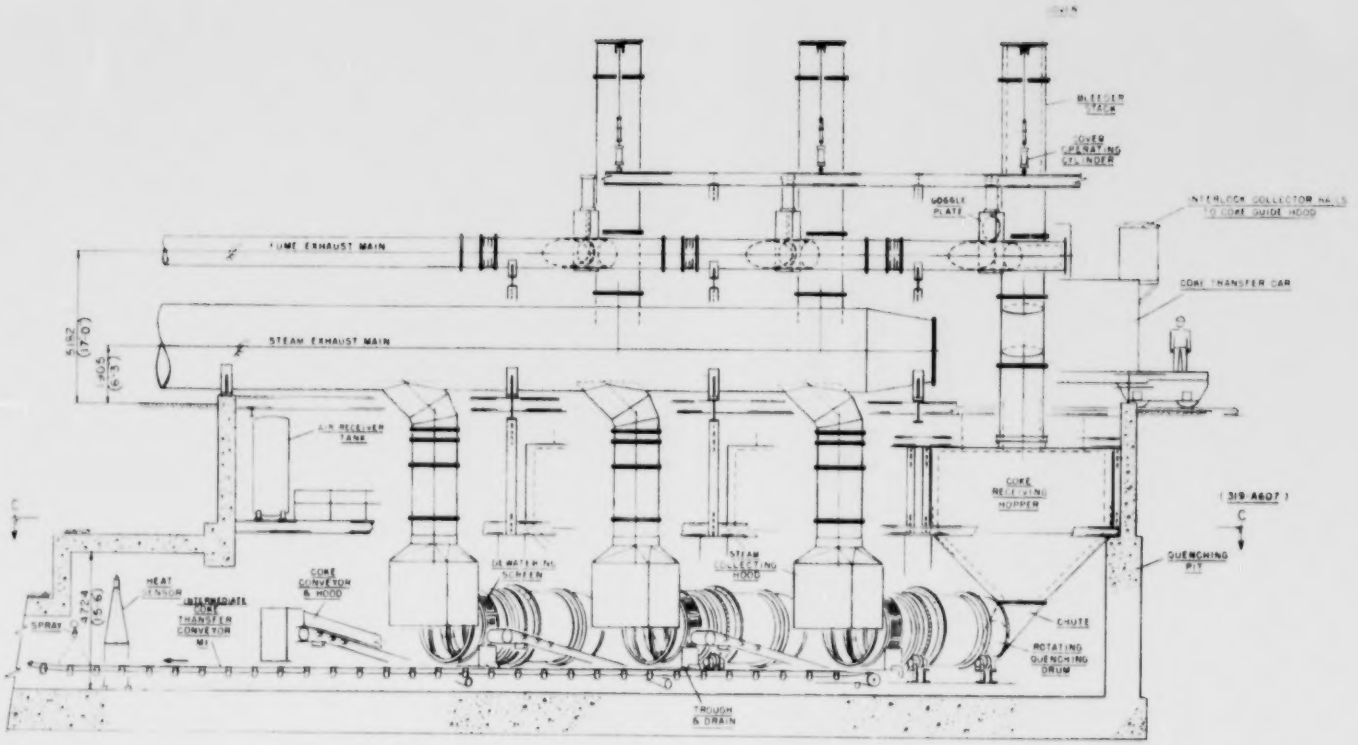
PLAN

Figure 9

REVISED 12-4-80

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
QUENCHING PIT GEN ARRANGEMENT

DRAWN BY	W S WHITE	DATE	OCT 27, 72	SCALE	3/16-1-0	319-A604



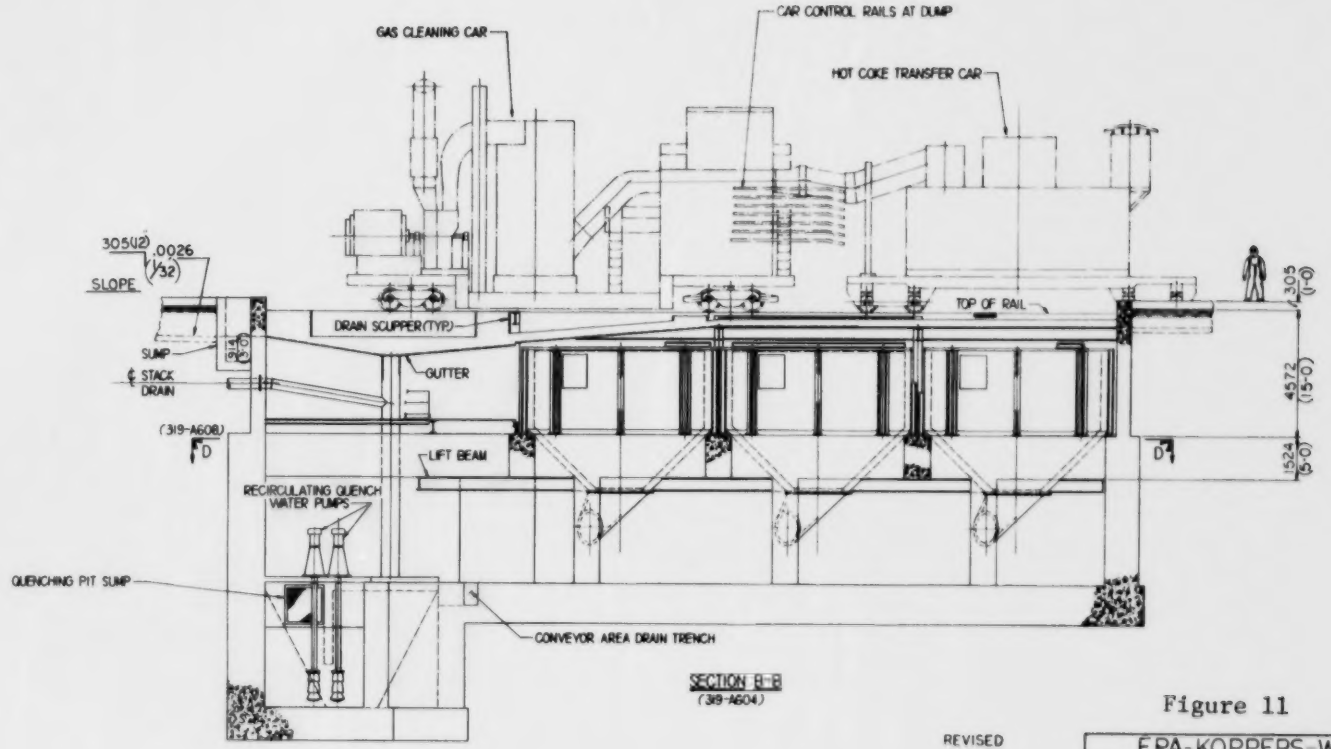
SECTION A-A
(319-A604)

Figure 10

REVISION
12-4-80

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
QUENCHING PIT SECTION A-A

DRAWN BY	A.S. WHITE	DATE	OCT. 27, 78	SCALE	1/8" = 1'	319-A605



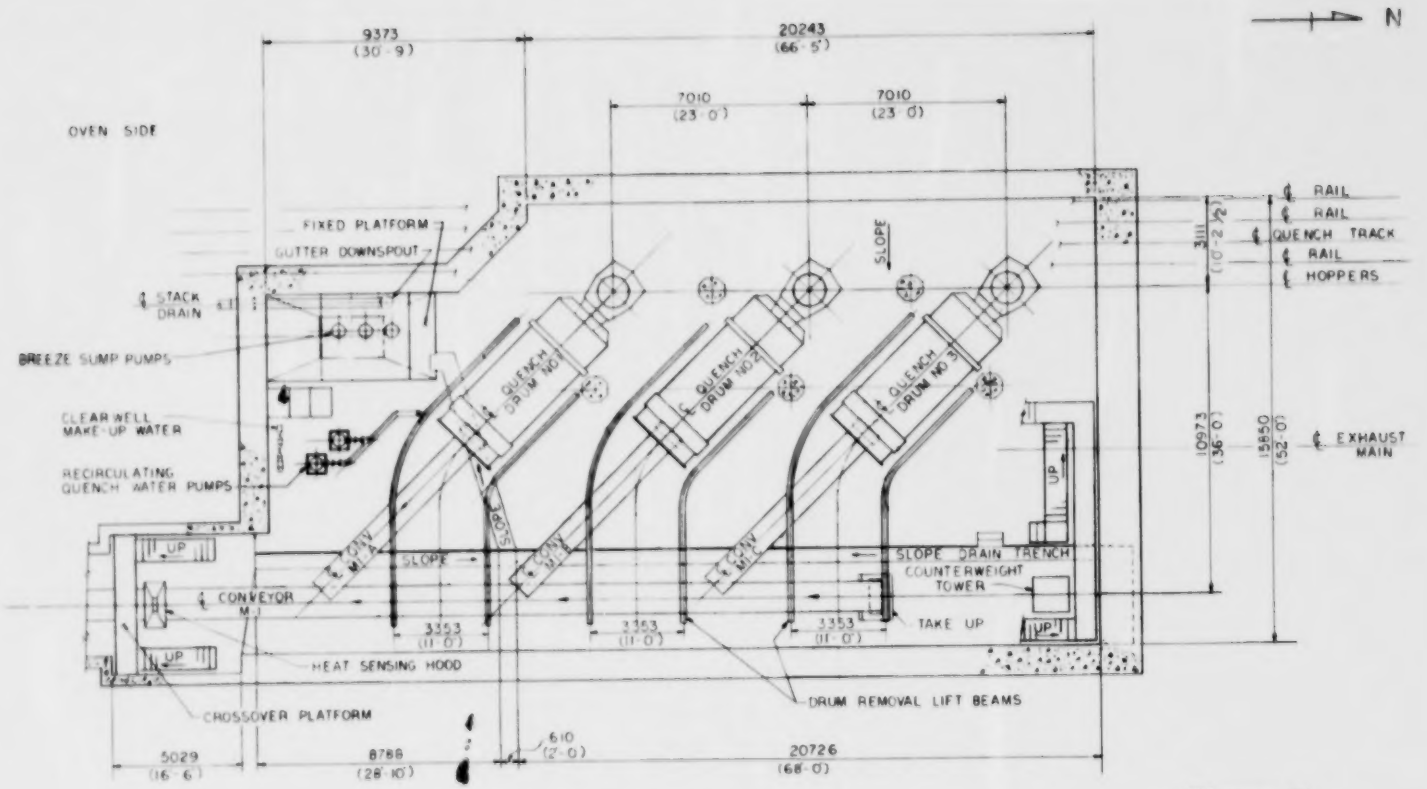
SECTION B-B
(319-A604)

REVISED
12-4-80

Figure 11

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
QUENCHING PIT ——— SECTION B-B

DRAWN BY	W.S. WHITE	DATE	OCT 30, 72	SCALE	3/16"=1'-0"	319-A606

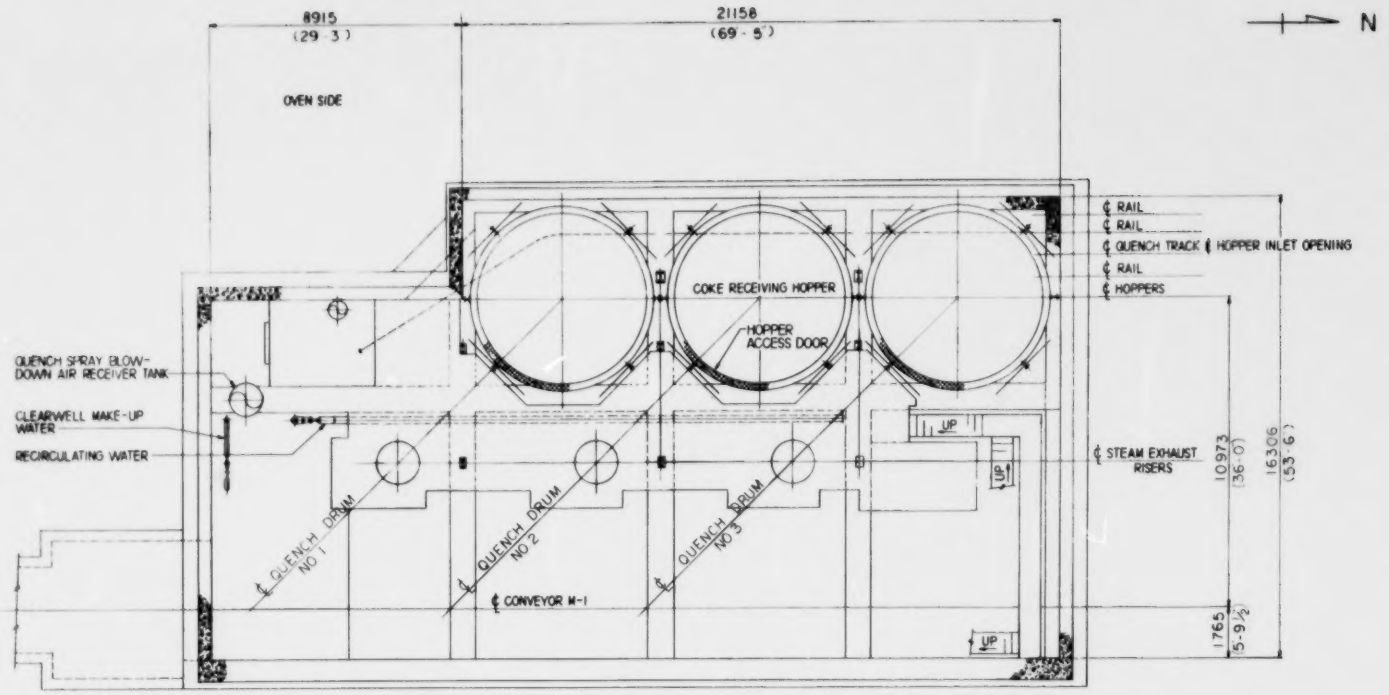


SECTION C-C
(319-A605)

REVISED
12-4-80

Figure 12

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
QUENCHING PIT - SECTION C-C
DRAWN BY WS WHITE DATED OCT 19 72 SCALE 3/16"-1'-0" 319-A607



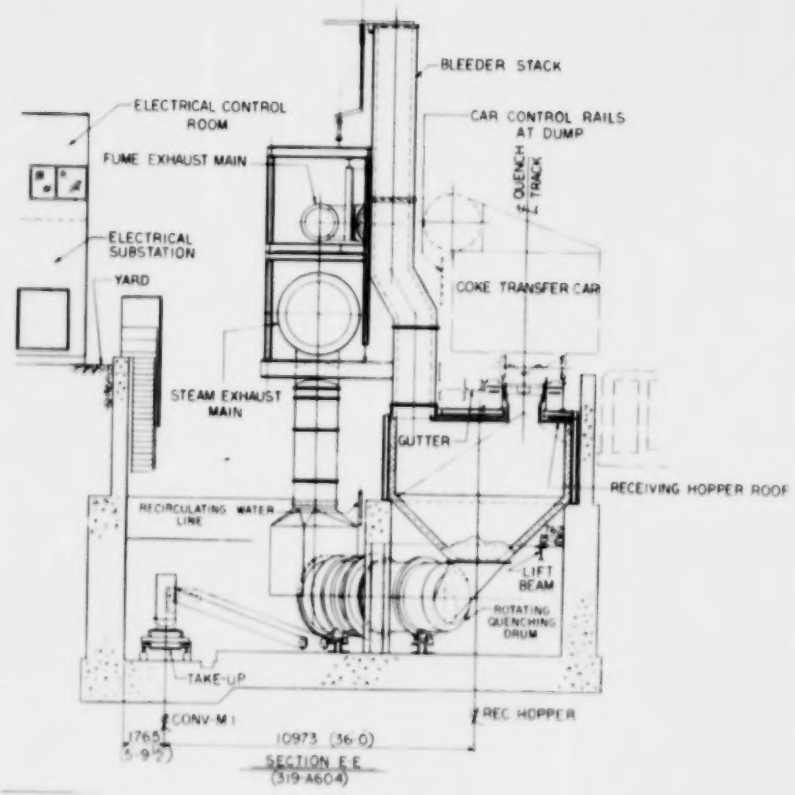
SECTION D-D
(319-A606)

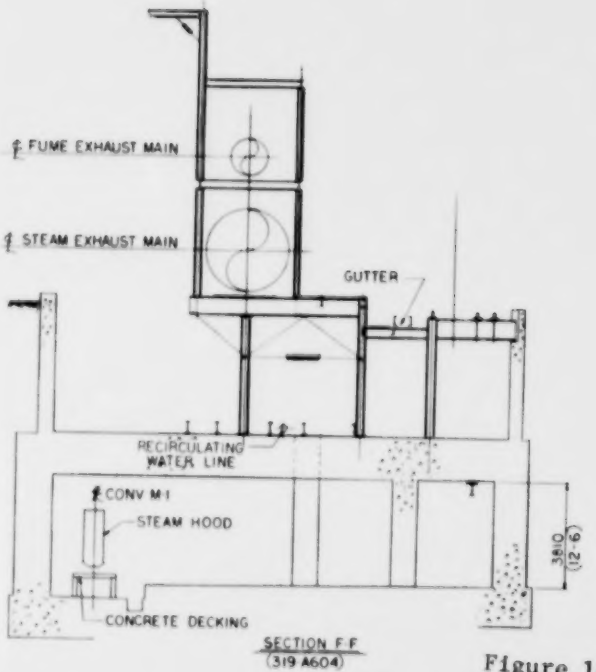
Figure 13

REVISED
12-4-80

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
QUENCHING PIT — SECTION D-D

DRAWN BY	W.S.WHITE	DATE	OCT. 20 '72	SCALE	3/16"=1'-0"	319-A606





REVISED
12-4-80

Figure 14

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
QUENCHING — SECT. E-E & F-F
DRAWN BY W.S. WHITE DATE OCT 9, 72 SCALE 1/16"-1'-0" 319 A609

E. Coke Receiving Hoppers (Figures 9 thru 14)(cont'd) conditions, two hoppers were utilized with the third hopper available as a spare. Each hopper is formed of steel plate and lined with refractory brick and has a charging hole 1.07 meters by 4.27 meters (3.5 feet by 14 feet) in the top. This rectangular opening is slightly larger than the opening in the hot coke transfer car to facilitate discharging. Sliding gates for the receiving hopper charging holes are provided to prevent gas escape between the discharges of coke from the car. Each gate system is operated by directly connected pneumatic cylinders. An interlock timer for each hopper's gate system prevents the coke from being dumped into the same hopper until a pre-set time has elapsed permitting the hopper to empty. Also a red light at the dump area for each hopper indicates that the Operator should travel to the other available hopper if the full time has not elapsed. The sliding gates of the hoppers open upon a signal from the gas cleaning car cab console, provided the hopper runout time has elapsed. When the Gas Cleaning Car Operator causes the hot coke transfer car gates to start to close after dumping the coke, the receiving hopper gates begin to close, and then the fume exhaust main flow control valves reposition, cutting off flow to the steam-hydro gas cleaning equipment and directing flow to the fume combustion system bleeder stack.

E. Coke Receiving Hoppers (Figures 9 thru 14)(cont'd.)
Near the top of each hopper is a castable refractory-lined offtake duct which channels gas to the fume exhaust main or to the hopper's fume combustion system bleeder stack. The flow direction is controlled by valve positioning. Further description is provided in Section H.

Each hopper has a working capacity for one load of coke from the hot coke transfer car. Since it requires approximately 18 minutes to discharge one hopper of coke to its quench system, it becomes necessary to drop the second load of incandescent coke into the other operating hopper (or the third hopper in an emergency).

On the bottom of each coke receiving hopper is a discharge chute which controls the rate at which hot coke is fed to the rotary drum quench conveyor. The maximum hot coke feed rate is 77.1 metric tons per hour (85 tons per hour) and the normal rate is 72.6 metric tons per hour (80 tons per hour) based on a 15.4 hour gross coking time.

F. Coke Quenching Drums (Figures 9 thru 14)
Rotary drum quench conveyors receive hot coke from the coke receiving hopper discharge chutes. There is one rotary drum quench conveyor per coke receiving hopper. Each drum has interior screw flights which convey the coke as it is quenched by water sprays. The water spray header is mounted along the center axis of the drum. At the discharge end of each rotary drum quench conveyor the quenched coke is fed onto a belt conveyor called the intermediate conveyor. Manually adjustable sprays are provided above

F. Coke Quenching Drums (Figures 9 thru 14)(cont'd) the intermediate conveyors for additional quench capability, if required. Each intermediate conveyor discharges onto M-1 belt conveyor.

G. Spray Water and Steam Exhaust Systems (Figures 9 thru 14)

In order to cool the hot coke, water is sprayed on the coke at a controlled rate of approximately 102 Cu.M/Hour (450 g.p.m.) by five banks of sprays which are located inside the rotary drum quench conveyors. The tumbling action and movements of the coke inside the revolving drum causes extensive water-coke contact. A sixth spray bank, located along M-1 belt conveyor, is activated through heat sensors only when high coke temperature is evident beyond the fifth spray bank.

The runoff water is collected in a floor channel and returned to a breeze sump. From this breeze sump the water and solids are pumped to a yard level settling tank. In the settling tank the water and solids separate with clarified water flowing over a weir into a clearwell where it drains by gravity to the recirculating pump clearwell. The clarified water is recirculated by one of two pumps to the sprays inside the rotary drum quench conveyors or onto M-1 belt conveyor in conjunction with hot coke sensors. The solids which are collected in the settling basin fall to the bottom from where they are dredged and deposited into a container for disposal or onto M-1 belt conveyor. If the recirculating water pumps at the clearwell fail,

G. Spray Water and Steam Exhaust Systems (cont'd)
an emergency water system is utilized to quench any coke remaining in the track hoppers and inside the rotary drum quench conveyors. This emergency system is controlled by the Quenching Station Operator who is warned of pump failure by appropriate alarms.

Each rotary drum quench conveyor has an exhaust hood enclosure constructed of removable stainless steel panels, with access doors for inspection of the screw flights, sprays and dewatering screens. At the top of each flared hood is an exhaust duct fitted with a mist suppressor and a flow control valve which channels the steam generated during quenching to the steam exhaust main. Downstream of exhaust ducts, the steam exhaust main is provided with a stainless steel axial flow fan for positive steam withdrawal. The steam flows across the fan and is discharged into an exhaust stack. A wooden louver mist suppressor is provided inside this stack to remove entrained water and particulate matter. Water sprays are located above the suppressor to backwash the baffles. The resulting wastewater is discharged to the recirculating quench water sump.

H. Coke Hopper Fume Exhaust and Gas Cleaning System (Figures 9 thru 14)
At the top of each coke receiving hopper is exhaust ductwork which is independent of the steam withdrawal system. This ductwork consists of two sections, one for fumes and combustion gases

H. Coke Hopper Fume Exhaust and Gas Cleaning System (Figures 9 thru 14) (cont'd)

from the incandescent coke in the hopper and the other for the initial coke dumping period when the steam-hydro gas cleaning equipment is used for handling the large volume of air and gas which is generated (Figures 10 and 14). This large volume comes from the quick displacement of air by the coke dropping into the hopper as well as from the burning of the incandescent coke while falling. It is, therefore, necessary to use the volume and pressure characteristics of the steam-hydro gas cleaning equipment to withdraw this large volume until the coke has been dumped and the track receiving hopper gates closed. This is a short interval compared to the residence time of the coke within the hopper.

The exhaust ductwork rises vertically from the top of each hopper to a "T" section with one leg leading to the fume main connecting all three hoppers to the steam-hydro gas cleaning equipment. Valving is used to control gas flow to either "T" leg with interlocking provided to limit flow to one or the other, but not both.

When the hot coke transfer car has been spotted over the proper track receiving hopper, the Operator initiates the dump cycle which positions system flow control valves for flow to the steam-hydro gas cleaning equipment. After the valves are in position the steam-hydro gas cleaning equipment is activated and the coke is dumped. While on line, the gases and particulates are pulled from the coke receiving hopper through the

H. Coke Hopper Fume Exhaust and Gas Cleaning System (Figures 9 thru 14) (cont'd)

castable refractory-lined fume main to an unlined pre-quench section where the gases are cooled and saturated and heavier particulate is knocked out with water sprays. Beyond the pre-quench section the gases and particulate enter the steam-hydro gas cleaning equipment which consists of two steam jet ejectors (to create suction) with scrubbing water injection sprays, mixing tubes (to contact scrubbing water with remaining particulate) and cyclonic separators (for moisture and particulate separation) in a series arrangement. The slurry discharge from the cyclonic separators enters a seal pot which drains to the quench pit breeze sump and the cleaned gas is discharged to the exhaust system stack (Figure 9). At completion of the dump operation the steam-hydro gas cleaning equipment is deactivated and track hopper gates are closed as the system flow control valves are repositioned. With the flow valves in position the combustion system bleeder stack is vented to the atmosphere creating natural draft on the track hopper. This arrangement provides a channel for any combustible gases, that may be generated, to flow to an electric igniter mounted at the discharge of each bleeder stack for combustion before the release to the atmosphere. The exit of each bleeder stack is fitted with a cap valve for flow control and as a relief for pressure surges in the system.

J. Emergency Coke Dump Pit (Figure 15)

On the north side of the continuous quenching system is an emergency coke dump pit. This is used only when the continuous quenching system is inoperable and the hot coke transfer car contains a load of incandescent coke which must be dumped. When this condition is encountered the transfer car passes through the track hopper area to the emergency dump station. The car is manually positioned over the pit which has reenforced concrete sides with a firebrick lining and is capable of holding one load of coke. It is open on the east side with a concrete approach ramp so that the coke may be removed by a front-end loader. There is a spotting interlock which must be satisfied in order to open the coke car gates.

To cool the hot coke, three banks of sprays are located at the top of the pit, with five sprays per header. A manual shut-off valve which regulates the service water to the sprays is located adjacent to the pit. The Car Operator dumps the load of coke into the pit, leaves the car and goes to the valve station where the water valve for quenching the coke is opened for the required time and is then closed. Thereafter the standard coke quenching car must be employed until the continuous quench system is in operation again.

The runoff from the emergency quench is collected in a sump and is discharged into the quench track drainage trench which runs back to the breeze sump in the continuous quench station pit.

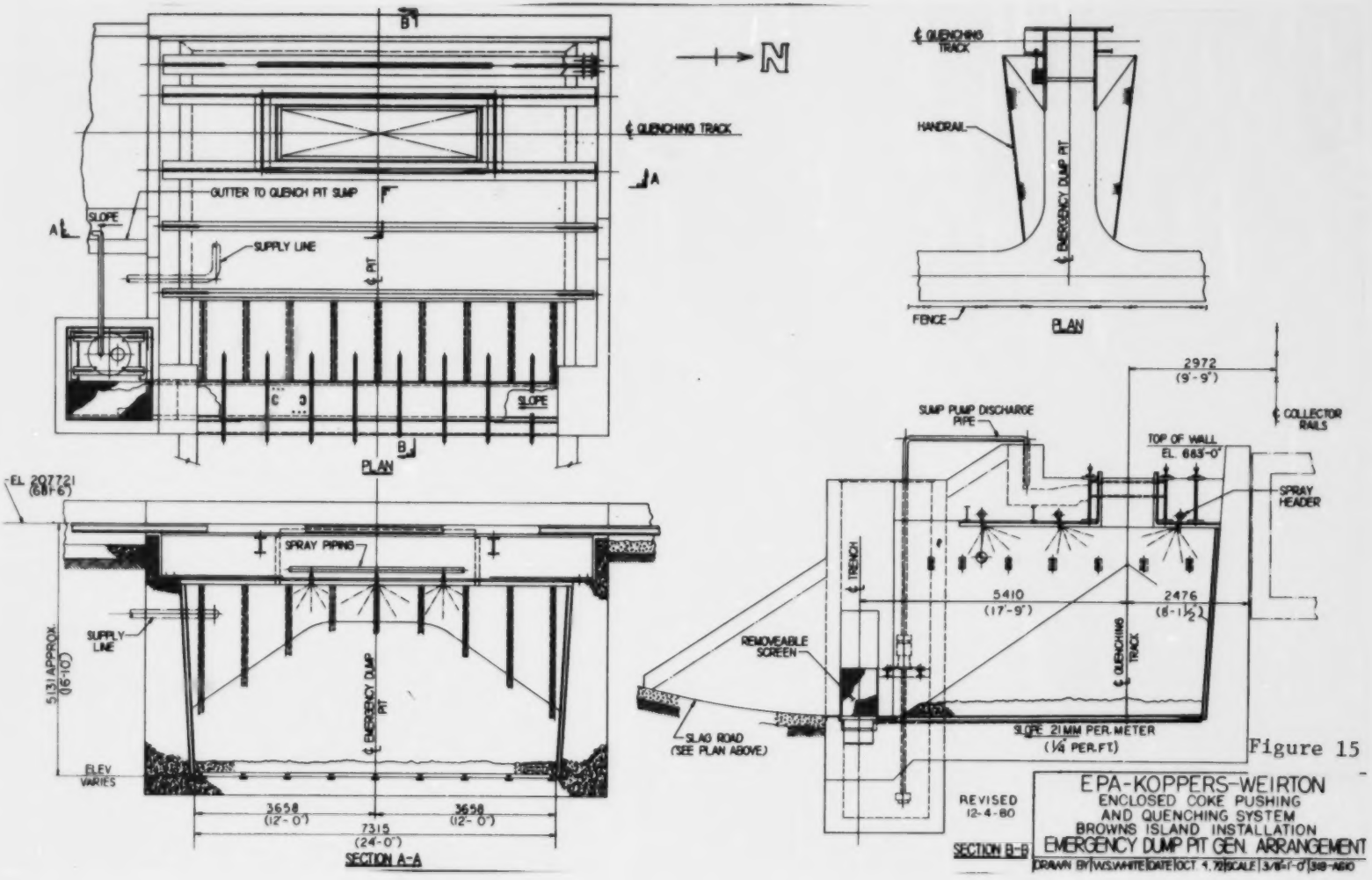

B
N
℄ QUENCHING TRACK
A
GUTTER TO QUENCH PIT SUMP
SLOPE
SUPPLY LINE
℄ PIT
SLOPE
B
PLAN
EL 207721 (681-6)
SPRAY PIPING
SUPPLY LINE
5131 APPROX. (16-10)
℄ EMERGENCY DUMP PIT
ELEV VARIES
3658 (12-0")
7315 (24-0")
3658 (12-0")
SECTION A-A
℄ QUENCHING TRACK
HANDRAIL
℄ EMERGENCY DUMP PIT
FENCE
PLAN
2972 (9'-9")
SUMP PUMP DISCHARGE PIPE
℄ COLLECTOR RAILS
TOP OF WALL EL 683'-0"
SPRAY HEADER
℄ TRENCH
5410 (17'-9")
2476 (8'-1½)
REMOVEABLE SCREEN
℄ QUENCHING TRACK
SLAG ROAD (SEE PLAN ABOVE)
SLOPE 21 MM PER METER (¼ PER FT)
REVISED 12-4-80
SECTION B-B
EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
EMERGENCY DUMP PIT GEN. ARRANGEMENT
DRAWN BY W.S.WHITE DATE OCT. 1, 21 SCALE 3/16"-1'-0" 348-A610

Figure 15

K. Emergency Coke Quenching System and Wharf (Figures 16 thru 18)

In case of an extended downtime at the continuous coke quenching station an emergency quenching station is available at the south end of the battery. The regular enclosed coke transfer car is not adaptable to the conventional quenching system; therefore, a standard 40-foot quench car with a sloped bed (Figure 16, Drawing #319-A612) is employed using the gas cleaning car as the method of moving the coke car.

The quenching station is located at the south end of the battery and the emergency coke wharf is located midway between the station and the continuous quenching site. The quenching station (Figure 17) is an open type with overhead sprays which are operated from a control room by the Car Operator. The dirty water is collected in a sump and pumped to a trench which drains to the breeze sump at the continuous quenching pit.

After the coke has been quenched, the gas cleaning car pulls the quenching car to the emergency coke wharf (Figure 18) where the coke is dumped.

L. Coke Handling (Figures 9 thru 14)

The quenched coke from the rotary drums is discharged to an intermediate belt conveyor system which, in turn, discharges the coke onto the M-1 belt conveyor. The M-1 belt conveyor transports the coke to a junction point just below yard level where it discharges onto the M-2 conveyor belt. The M-2 conveyor belt carries the coke

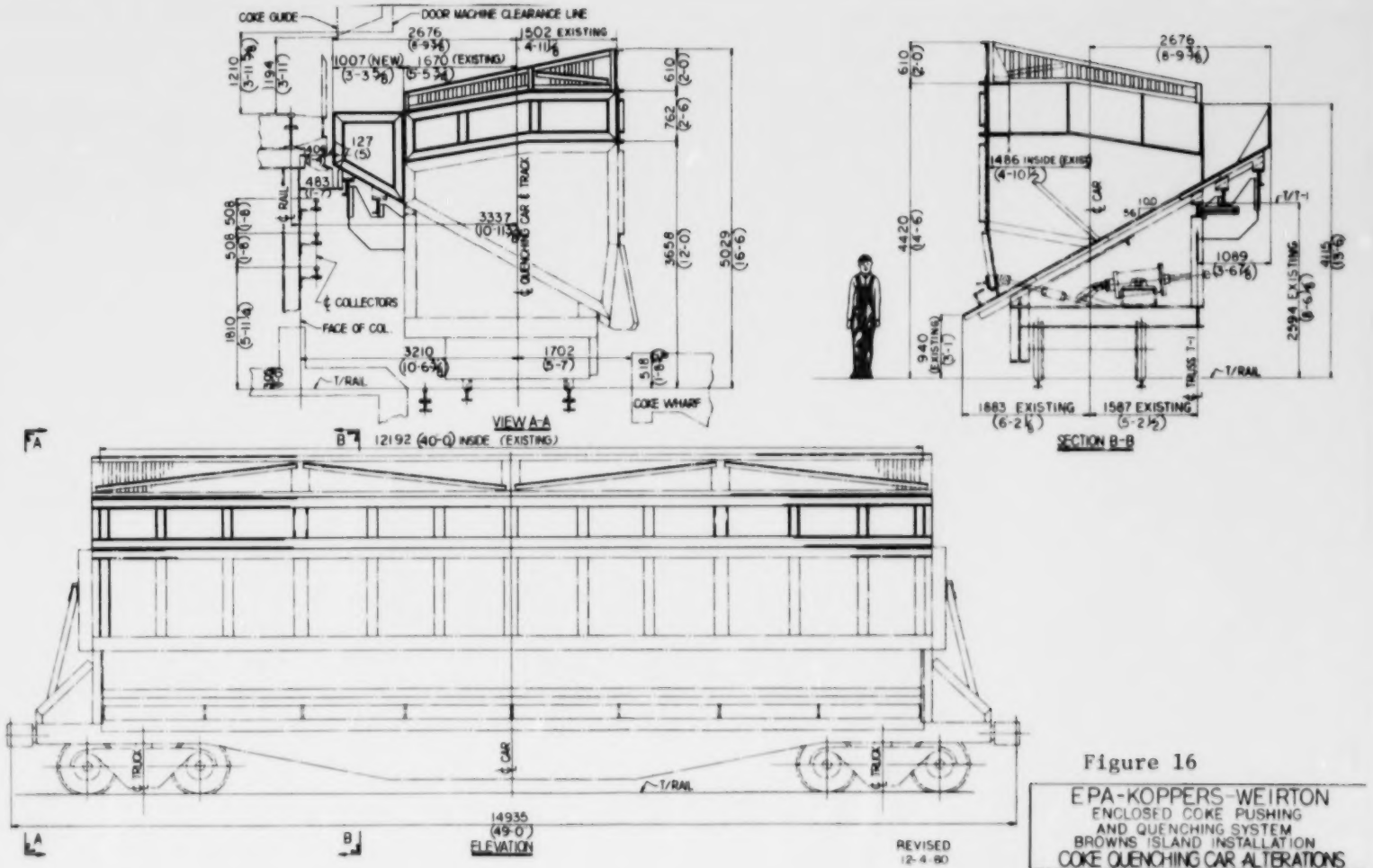


Figure 16

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
COKE QUENCHING CAR ALTERATIONS

DRAWN BY W.S.WHITE | DATE OCT 11, 72 | SCALE 1/2"=1'-0" | 319-4812

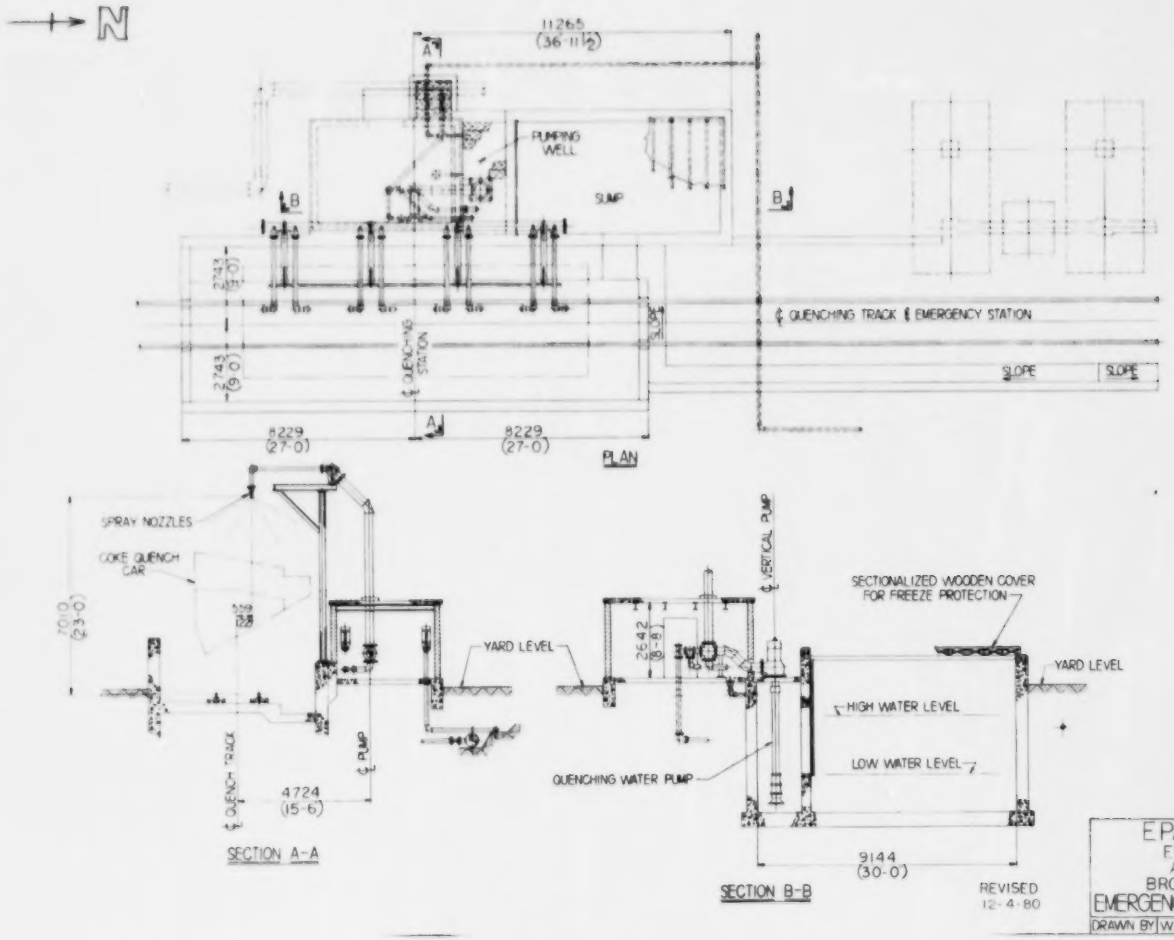
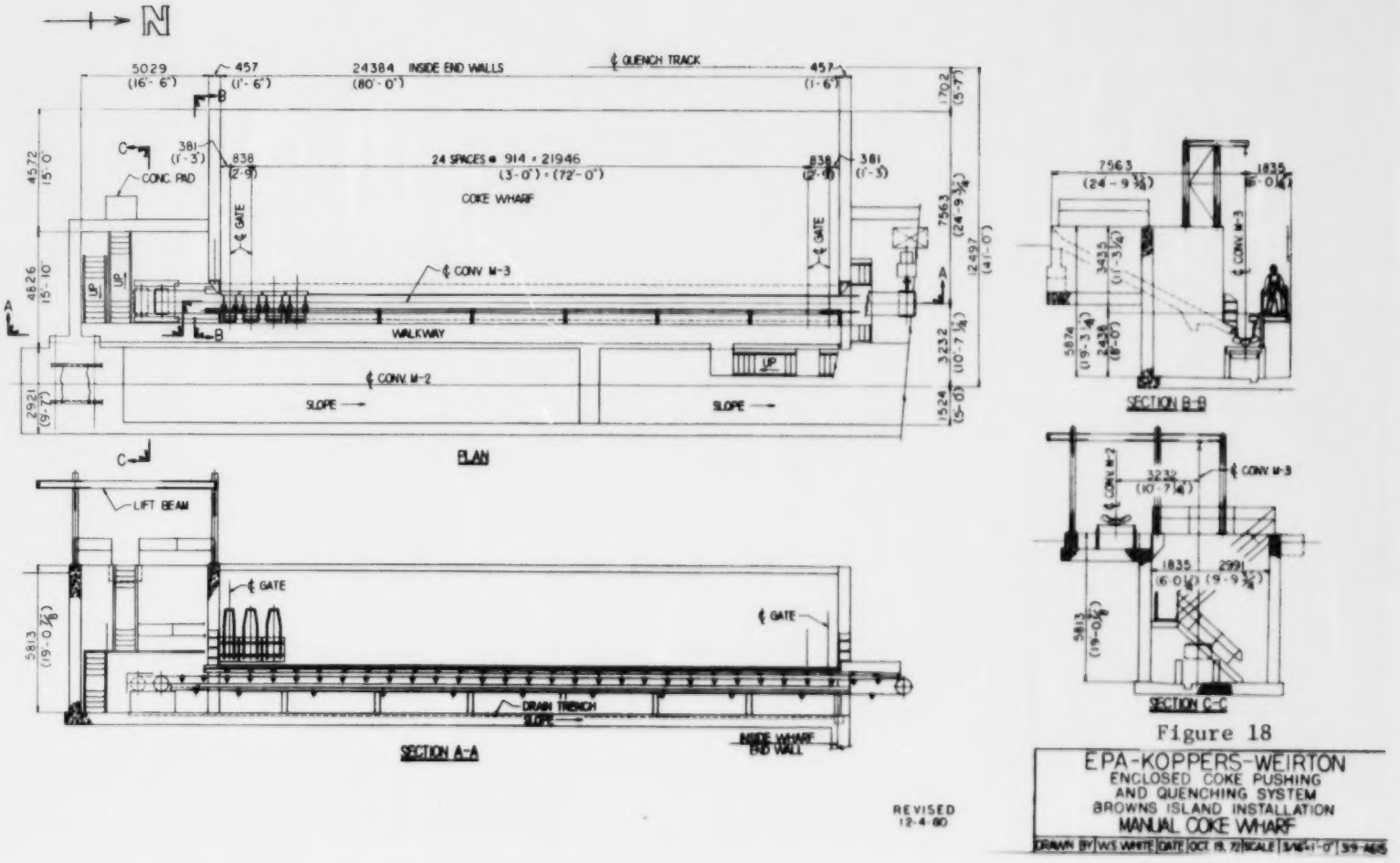


Figure 17

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING
AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
EMERGENCY QUENCHING STATION SECTIONS

DRAWN BY	W.S.WHITE	DATE	OCT. 5, 72	SCALE	3/16"=1'-0"	319-A611



REVISED 12-4-80

Figure 18

EPA-KOPPERS-WEIRTON
ENCLOSED COKE PUSHING AND QUENCHING SYSTEM
BROWNS ISLAND INSTALLATION
MANUAL COKE WHARF

DRAWN BY W.S. WHITE | DATE OCT. 19, 72 | SCALE 1/16"=1'-0" | 39-A05

L. Coke Handling (Figures 9 thru 14) (cont'd)

to the top of the loadout bin. These conveyor belts are also interlocked to prevent M-1 from running if M-2 is stopped and M-2 cannot be run if the loadout bin is full. The coke from the emergency wharf is fed onto a conveyor belt (M-3) by an Operator using manual gates. The coke is transferred from the M-3 Conveyor to M-4 Conveyor and then to the M-2 Conveyor which leads to the loadout bin.

The 150-ton capacity quenched coke loadout bin has a double gated discharge at the bottom. High level probes at the top of the bin control the coke conveyor belt to prevent overloading of the bin. A coke bypass flop gate can be operated in case the bin becomes full, whereby the coke is discharged from M-2 Conveyor across the flop gate into a discharge chute to the ground. Normally, the coke from the storage bin will be loaded into trucks. The Truck Operator will be able to observe and control the coke loading procedure from the cab of his truck through the use of a television monitor and a carrier type transmitter and receiver for operation of the hopper gate. In order to minimize the fugitive dust from the coke handling system, a dust collector as well as a vacuum cleaning system are provided.

SECTION IV

EVALUATION OF THE ENCLOSED COKE PUSHING AND QUENCHING SYSTEM

SECTION IV-A - OPERATING PROBLEMS

Numerous problems have prevented the continuous operation of the enclosed coke pushing and quenching system since it was commissioned in 1973. Efforts to resolve these problems have resulted in the implementation of many programs which have cost the Company millions of dollars. Significant progress has been made in improving the operability of the system; however, continuous operation has still not been achieved due to potential explosive hazards associated with the gas cleaning car. Additional expenditures will be required to eliminate this problem and insure the safety of the system. In addition, the operating and maintenance costs associated with the underground quenching facilities are considered excessive, and consideration is presently being given to the replacement of these facilities.

The following significant operating problems were encountered during the operating period from 1973 through 1980:

1. Problems Due to Thermal Damage, Abrasion and Corrosion
   a. Underground Coke Hopper Gates (Thermal Damage)
   b. Underground Coke Hopper Roofs (Thermal Damage)
   c. Quenching Facilities (Abrasion)
   d. Recirculated Water Systems (Abrasion)
   e. Gas Cleaning Systems (Abrasion and Corrosion)
2. Problems due to Explosive Hazards
   a. Underground Coke Hoppers
   b. Gas Cleaning Car

A synopsis of these problems is presented in the following paragraphs. Detailed background information concerning the explosive hazards encountered in the system is documented due to the serious nature of this problem.

1. Problems Due to Thermal Damage, Abrasion and Corrosion

   a. Underground Coke Hopper Gates

      The life of the underground coke hopper gates and pneumatic cylinders has been extremely short due to the high temperature environment to which they are subjected. These failures have affected the operability of the underground quencher more than any other single problem in this category. During the first five years of operation, more than fifty percent of the downtime was associated with the failure of the hopper gates and/or pneumatic cylinders. The gate and pneumatic cylinder failures are interrelated. A distorted gate can cause a short life for a pneumatic cylinder due to the release of large quantities of heat to the atmosphere. In turn, a malfunctioning pneumatic cylinder will cause rapid heat distortion if the gates fail to close. In addition, the release of heat from the underground coke hopper can result in damage to the gas cleaning car during the transfer of coke to an adjacent underground hopper.

      Early programs for improvement which were not successful included the installation of carbon steel slab gates and stainless steel gates with water cooled shafts. An improvement was achieved when the pneumatic cylinders were relocated from the middle to the end of the gate shaft, and high temperature packing was in-

a. Underground Coke Hopper Gates (contd.)
stalled. However this modification, in combination with the installation of cast iron gates, resulted in only a minimal increase in gate life. At this point it became obvious that a complete re-design of the gate system would be necessary. The new design is similar to that utilized for steel mill ingot soaking pit covers. The hinged gates were replaced with refractory lined sliding covers which move parallel to the tracks that support the gas cleaning and coke transfer cars. Due to the close proximity of the underground coke hoppers, split cover systems with dual pneumatic cylinders were utilized. The installation of the new refractory lined sliding covers has resulted in a major improvement in the operability of the system. However, the maintenance requirements for this coke hopper enclosure system are significant.

b. Underground Coke Hopper Roofs
Refractory failure in the roofs of the coke hoppers was a major problem during the first four years of operation of the system. The original roof was constructed with steel plate, a wire screen support grid and spray-type refractory. This design proved to be inadequate in that roof life was less than three months. Replacement of the wire screen support grid with stainless steel clips improved roof life, but not to a satisfactory level. A total redesign of the coke hopper roof was completed in 1975. The new design specified the replacement of the existing steel roof plate and the

b. Underground Coke Hopper Roofs (cont'd.)
addition of modified I-beams to support notched refractory brick. The installation of these hanging refractory roofs as replacements for the spray refractory roofs has eliminated this problem.

c. Quenching Facilities
When the system began operation in June 1973, the hot coke was discharged from the underground hoppers onto vibrating conveyors where it was quenched by overhead water sprays. Immediately following the start-up of this system, it became evident that excessive abrasion and wear problems were associated with the feeder and main section of the vibrating coke conveyors. Efforts to minimize these problems during the first four months of operation were unsuccessful and the development of an alternate quenching system was necessary. A study of the alternatives available to the Company, at that time, indicated that the most promising proposal was the replacement of the vibrating conveyors with rotary drums. In order to establish the practicality of this concept, a pilot rotary drum quencher was installed and a testing program was completed. The result of these tests was sufficiently encouraging that a program was immediately established to replace the vibrating conveyors with rotary drums. The installation of the rotary drums minimized the abrasion problem and permitted the uninterrupted operation of the quencher. However, abrasion and wear continue to be a significant problem in that reconditioning programs are frequently required for the underground coke hopper discharge chutes and the rotary drums.

c. Quenching Facilities (cont'd.)

Abrasion problems also adversely affected the performance and life of the axial steam exhaust fans for the rotary drum quenchers. The poor performance of these fans resulted in their replacement with a larger axial exhaust fan, a new steam exhaust main section, and three new mist suppressors, one for each vertical duct located between each rotary drum and horizontal steam exhaust main.

d. Recirculated Water System

A serious operational problem was encountered immediately after the start-up of the system in that the facilities provided to handle and segregate the coke breeze and fines generated in the gas cleaning, transferring, and quenching processes were inadequate. As a result, in the early stages of operation, pump life was extremely short due to abrasion and wear problems.

The gas cleaning car encountered difficulty due to particulate and breeze plugging of the gas cleaning recirculating water system. The quantity of solids collected in the recirculated water was larger than expected. Physical changes to the configuration of the water separator reservoir, piping and the mechanism for discharging wastewater were initiated to minimize the plugging and abrasion problems. In addition, the severity of the problem was also decreased by increasing the blowdown rate from the recirculated water system between pushing cycles.

d. Recirculated Water Systems (cont'd.)

A similar problem was encountered within the recirculation system for the underground quenching facility. The capacity of the coke breeze sump upstream of the clearwell for the recirculation pumps was inadequate, and it was necessary to expand these facilities. Additional pumps were installed with the necessary piping to transport the breeze laden wastewater from the underground pit to the surface where a circular settling tank was constructed. The decanted water is returned to the recirculating water pump clearwell within the pit. The coke breeze in the settling tank is periodically removed by a clamshell bucket operated from a mobile crane.

The Company has worked closely with pump manufacturers to implement programs for improvement of the system. These programs have included alternate pump and impeller designs. The pump performance and life in the recirculated water systems have improved considerably over the years, but maintenance requirements associated with the underground quenching system are considered excessive.

e. Gas Cleaning Systems

Corrosion problems in the cyclone separator in the coke hopper gas cleaning system became evident during the first year of operation. The mildly acidic effluent from the scrubber attacked the carbon steel housing of the separator. The scrubber was unaffected since it was constructed of stainless steel. Two programs were immediately initiated to minimize the corrosion problem. The first program, considered short term, entailed the

e. Gas Cleaning Systems (cont'd.)

reconditioning of the existing separator and the application of a protective coating to its inner surface. The second program called for the fabrication and installation of a stainless steel cyclonic separator.

The corrosion problem eventually expanded to the carbon steel exhaust fan in the system resulting in the installation of the stainless steel housing and impeller. Although the installation of the stainless steel components resolved the corrosion problem, the entire gas cleaning system was eventually scrapped due to the explosive hazard described in Section IV-A-2 of this report.

Corrosion problems of a lesser degree were also associated with the gas cleaning car. Periodically it has been necessary to replace or recondition the carbon steel components within the gas cleaning system. In situations where it has been cost effective, the carbon steel components were replaced with stainless steel components.

2. Problems Due to Explosive Hazards

In late 1974, an explosion occurred in the ventilation system for the underground coke hoppers. The explosion originated in the vicinity of the exhaust fan and resulted in significant damage to the system. This incident raised serious questions concerning the safety aspects of the system and a formalized testing program was initiated to establish the cause of the explosion.

Sampling ports located before the orifice washer, after the separator, and after the fan were utilized in the test program. The gas stream was monitored with a portable explosimeter to determine if and when an ex-

2. Problems Due to Explosive Hazards (cont'd.)

plosive mixture of gas existed during the quench cycle. The results of the monitoring indicated that an explosive mixture was present and existed for time periods lasting up to one minute. It was evident, after monitoring several transfers of coke to the hoppers, that the explosive gas mixtures were occurring at regular intervals which corresponded to the time period when the water sprays for cooling the gas stream were activated by thermocouples which detect excessive gas temperatures. Samples of the gas stream were taken during time intervals when the explosive gases were present and analyses were performed by gas chromatographic techniques. The analytical results showed hydrogen compositions in excess of the lower explosive limit of 4.1 percent by volume for hydrogen. At this point it was theorized that water from the sprays was draining down into the hot coke and producing a water gas rich with hydrogen. The production of water gas is carried out by the reaction of steam on incandescent coke at a temperature in excess of 1800° F according to either of two reactions:

$$C + H_2O\ (g) \longrightarrow CO\ (g) + H_2\ (g)$$ or

$$C + 2H_2O(g) \longrightarrow CO_2\ (g) + 2H_2\ (g)$$

This theory was tested by completely excluding the water from the ductwork sprays during several transfer operations. The gas stream was monitored as in the previous tests and no significant readings were noted on the explosimeter. After several test runs, it was concluded that the theory advanced was correct and that a water gas reaction was occurring producing potentially explosive gas mixtures in the hopper fume exhaust system. The source of ignition that caused the explosion was not definitely established, but it was presumed to be the exhaust fan.

2. Problems Due to Explosive Hazards (cont'd.)

The coke hopper exhaust system was a combination of refractory lined and unlined ductwork. The water sprays in this exhaust system were necessary to cool the effluent gases and minimize thermal damage to the unlined ductwork. Since the sprays could not be eliminated without major modifications to the system, corrective actions were implemented to isolate the water from the coke hoppers. The water sprays were relocated and drain line-seal pot systems were installed for each set of sprays in the main exhaust duct adjacent to each coke hopper. A new section of refractory lined duct was installed for each hopper to the main exhaust on a sufficient incline to prevent water from entering the hoppers. A combustion analyzer and recorder were installed in the control room to continuously monitor the fume hopper gas stream. The combustion analyzer was provided with an audible alarm which would be energized before an explosive condition was reached.

Testing of the system immediately after the completion of the above modification, in April 1975, indicated that explosive gas mixtures no longer existed in the system. However, the test program at that time was of short duration in that general economic conditions resulted in a nine-month suspension in coke production at the Brown's Island coke battery from May 1975 through January 1976. During the period from February through July 1976 the enclosed coke pushing and quenching system operated less than ten percent of the time due to problems associated with the underground coke hopper gates (see Section IV-A-1a). Explosive mixtures were not detected in the hopper exhaust system during this period.

2. Problems Due to Explosive Hazards (cont'd.)

In early August 1976 a second explosion occurred in the underground hopper exhaust system. This explosion was similar to the previous explosion which occurred in 1974 but the damage to the system was not as extensive. This incident demonstrated that the potential for an explosion was not eliminated with the implementation of the programs to isolate the gas cooling water from the underground hoppers. The system was immediately shut down and a complete investigation was conducted to determine the cause of the explosion. A thorough investigation of the hopper exhaust system indicated that the facilities, which were installed to isolate the gas cooling water from the coke hoppers, were operating properly and it was confirmed that water had not entered the hoppers from the exhaust system. All other components in the system were inspected, but the cause of the explosion was not definitely established. It was concluded that a controlled test program would be necessary to define the problem. In order to insure the safe operation of the system, it was further concluded that the test program could not proceed until the following facilities were installed:

a. A purge system which could manually and/or automatically inject liquid nitrogen into the fume hopper exhaust system when a dangerous condition was detected.

b. Improved combustible gas monitoring and recording instrumentation with provisions for a high limit alarm and activation system.

2. Problems Due to Explosive Hazards (cont'd.)

After the above facilities were installed, the testing program proceeded in two phases. The Phase I program was designed to determine whether explosive gas compositions were being generated during the coke pushing and transfer operations prior to the discharge of coke into the underground hopper system. The underground quenching system was not operated during this phase of the test program. The Phase II test program was designed to define the explosive hazards associated with the underground facilities.

PHASE I TEST PROGRAM

Sampling ports were located at the inlet ducting and exhaust stack of the gas cleaning-coke transport car. Gas samples were withdrawn from the port at twenty second intervals beginning at the start of the push and extending to the raising of the hood. Stack traverses were also performed to document the exhaust rate of the gas cleaning car fan. Sampling was conducted at two conditions (1) scheduled sixteen-hour coking; and (2) coke pushed two hours early to simulate conditions which represented higher than normal gaseous carry-over from the coal.

Table 1 summarizes the results from the gas cleaning car testing. As can be noted from this table, there is a definite difference between sixteen-hour coke and coke pushed early. Early coke showed significant values of hydrogen, carbon monoxide and methane. The lower explosive limit ranged between 0 percent to 364 percent with peak readings occurring at approximately forty seconds after the start of the push. As a contrast sixteen-hour scheduled coke did not have any methane or hydrogen and only a trace amount of carbon

TABLE 1 - SUMMARY GAS CLEANING CAR TESTING
TO IDENTIFY EXPLOSIVE HAZARDS

Parameter	14-HOUR COKE			16-HOUR COKE		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Hydrogen (H_2)-Volume %						
20 Seconds		7.5	3.0	0	0	0
40 Seconds	4.29	11.24	8.1	0	0	0
60 Seconds	0.94	7.0	2.7	0	0	0
Nitrogen (N_2)-Volume %						
20 Seconds	69.5	74.85	73.4	72.6	76.3	75.0
40 Seconds	62.31	74.55	69.0	76.27	79.3	77.2
60 Seconds	76.3	80.15	77.8	75.7	78.5	76.7
Oxygen (O_2)-Volume %						
20 Seconds	6.6	18.73	13.8	9.04	22.4	15.8
40 Seconds	3.3	8.2	6.1	2.81	14.0	7.6
60 Seconds	5.2	15.8	10.2	6.2	13.4	9.9
Carbon Monoxide (CO)-Volume %						
20 Seconds	0	1.9	1.04	0	0	0
40 Seconds	3.22	8.96	5.42	0.29	0.83	0.54
60 Seconds	0.7	3.2	1.42	0	1.02	0.37
Carbon Dioxide (CO_2)-Volume %						
20 Seconds	1.11	9.9	5.08	2.0	10.77	5.49
40 Seconds	5.23	7.5	6.60	8.1	16.78	12.57
60 Seconds	3.92	9.48	6.18	6.65	13.1	9.9
Methane (CH_4)-Volume %						
20 Seconds	0	1.17	0.68	0	0	0
40 Seconds	0.49	1.25	0.95	0	0	0
60 Seconds		0.28	0.17	0	0	0
Lower Explosive Limit % LEL						
20 Seconds	0	212	94.2	0	0	0
40 Seconds	140	364	260	2.3	6.6	4.3
60 Seconds	30.6	202	80.2	1.5	8.2	3.97

2. Problems Due to Explosive Hazards (cont'd.)

PHASE I TEST PROGRAM (cont'd.)

monoxide. The maximum calculated lower explosive limit was 8.2 percent.

PHASE II TEST PROGRAM

Phase II of the test program centered on the underground quench system and its auxiliary equipment. Sampling ports located at several points in the track hopper fume exhaust ductwork provided grab gas samples at the hopper vertical fume uptake and at a point downstream of the three hopper inlets in the track hopper fume main.

The combustible gas analyzer was installed at a point downstream of the track hopper fume exhaust orifice washer. The analyzer output was connected to solenoid valves on a liquid nitrogen purge system. The addition of liquid nitrogen was automatically initiated at 40 percent of the lower explosive limit in an effort to dilute the combustible gas prior to reaching the exhaust fan. Gas samples taken from the fume exhaust main were coordinated with high readings from the analyzer. Steam samples in the steam exhaust duct were also obtained and analyzed.

During this Phase II effort, various conditions were tested, which included the planned and unplanned shutdown of various components of the system. As testing proceeded, it became evident that a number of circumstances can exist that may contribute to a potentially explosive gas mixture in the exhaust system for the underground hoppers. Table 2 indicates typical analyses obtained during (A) the shutdown of one fan in the steam exhaust system, (B) the shutdown and start-up of the coke hopper fume exhaust fan, and (C)

2. Problems Due to Explosive Hazards (cont'd.)

PHASE II TEST PROGRAM (cont'd.)

normal operation of the system in which the exact cause of the high combustible gas concentration was not identified.

An immediate increase in combustible gas concentration was noted during the shutdown of the steam exhaust or coke hopper fume exhaust fans. It is theorized that steam exhaust fan outage increased the potential for steam back-flow into the track hoppers which can result in combustible gas generation. Coke hopper fume exhaust fan outage prevents the entry of adequate combustion air for burning the gases evolving from the hot coke, and high concentrations of combustible gas can also result. In both cases, combustible gas concentrations which are two to three times the lower explosive limit were recorded in the hopper vertical fume uptake.

Under normal operating conditions, it was found that combustible gas concentrations in excess of four times the lower explosive limit can occur in the hopper exhaust system, and it was concluded that the source of the combustible gas can originate from (1) gaseous carryover from the coal utilized to make coke, and (2) water gas reactions which result when water (steam) makes contact with incandescent coke. Unfortunately, it was found that the nitrogen purge system in the track hopper fume exhaust system was not controlling the combustible gas concentration below the lower explosive limit, and testing had to be terminated due to unsafe operating conditions.

2. Problems Due to Explosive Hazards (cont'd.)

The above test program defined numerous circumstances under which a potentially explosive mixture of gases can be generated within the system. The conditions which may have contributed singly or in some combination to the problem are (1) gaseous carryover from the coal utilized to make coke; (2)failure of any of the three steam exhaust fans; (3) failure of the hopper fume exhaust fan; (4) restarting of the hopper fume exhaust fan during operation; and (5) moisture (steam) infiltration into the coke hoppers causing a water-gas reaction. Due to the low operability and excessive maintenance problems, these conditions were occurring frequently. In addition, gaseous carryover and steam-water gas reactions must be considered as part of the normal coking operation and can occur at any time.

Gas samples taken and analyzed during these conditions, along with a continuous combustible gas analyzer located in the hopper fume exhaust ductwork, have conclusively defined a potentially explosive gaseous mixture existing in the ductwork of the coke hopper fume exhaust system. All samples taken from the quencher steam exhaust system during the test program were well below the lower explosive limit. Samples taken on the gas cleaning car with a fourteen-hour coking time indicated that gaseous carryover can produce a similar gas mixture. Based on gas chromatographic analyses of the gas samples, the mixture contains sufficient hydrogen, carbon monoxide and methane to exceed the lower explosive limit of the gas mixture.

2. Problems Due to Explosive Hazards (cont'd.)
Based on the results of this test program, it was concluded that the generation of potentially explosive gas compositions could not be totally eliminated in the underground hopper exhaust system and it was recommended that the system be modified to eliminate the ignition source. Although the source of ignition was not established in the investigation it was presumed to be the exhaust fan. A survey of alternatives led to the replacement of the orifice washer, cyclone and exhaust fan with a steam-hydro gas cleaning system. This system, which is described in detail in Section III-H of this report, utilizes a steam ejector to exhaust and clean the gases from the coke hoppers during the transfer operation. The system was commissioned in July 1979, and has eliminated the explosive hazard associated with the underground coke hoppers.

After the completion of the Phase I test program, there was also concern that long term deterioration of the battery heating system might eventually lead to the development of combustible gas problems in the gas cleaning car exhaust system. Unfortunately this problem developed sooner than expected. In March 1980, a mild explosion occurred in the vicinity of the gas cleaning car exhaust fan causing significant damage to the cyclonic separator and exhaust fan. The cause of the explosion was presumed to be due to excessive gaseous carryover from coke which was not totally carbonized in the oven. The gas cleaning car exhaust system was shut down and a survey of visible pushing emissions was completed to document ovens with heating and/or refractory problems. Based on the survey, the ovens were classified in one of three

2. Problems Due to Explosive Hazards (cont'd)

categories (good, marginal and poor) and a program was initiated to completely inspect and repair all inferior ovens. This program, which will be completed by mid-1981, consists of through wall repairs, end flue repairs and ceramic welding of damaged refractory.

After the gas cleaning car exhaust system was repaired, velocity traverses were performed to document the gas volume exhausted by the fan. This volume was found to be approximately forty percent less than the design volume of 1062 m^3/min. (37,500 acfm) due to excessive pressure drop in the system. However, based on the Phase I test data, it was concluded that even at the design flow, the existing fan was insufficient to insure the safety of the system.

The highest concentrations of hydrogen and/or carbon monoxide which were recorded during the operation of the system were utilized to calculate the volume required to dilute that gas to a safe concentration below the lower explosive limit. The minimum fan capacity necessary to eliminate the explosive hazard was calculated to be 1416 m^3/min. (50,000 acfm). A program is presently being initiated to modify or replace the gas cleaning car system. This program, which is presently in the design stage, should be completed in late 1982.

TABLE 2 - SUMMARY UNDERGROUND QUENCHER TESTING
TO IDENTIFY EXPLOSIVE HAZARDS

TABLE IIA: - Shutdown of One of Three Fans in Quencher Steam Exhaust System

Sample Location	H_2 Volume %	N_2 Volume %	O_2 Volume %	CO Volume %	CO_2 Volume %	CH_4 Volume %	Total Volume %	Lower Explosive Limit %
Hopper Vertical Fume Uptake	8.8	67.2	1.58	7.93	11.62	0.1	97.13	278

TABLE IIB: - Shutdown and Start-Up of Hopper Fume Exhaust Fan

Sample Location	H_2 Volume %	N_2 Volume %	O_2 Volume %	CO Volume %	CO_2 Volume %	CH_4 Volume %	Total Volume %	Lower Explosive Limit %
Hopper Vertical Fume Uptake	6.29	72.99	1.04	5.55	12.71	0.1	98.58	198
Hopper Fume Exhaust Main	2.14	75.25	9.31	2.75	7.85	0.1	97.3	74
Steam Exhaust Main	0	79	21	0	0	0	100.0	0

TABLE IIC: - Unidentified Combustible Source During Normal Operation

Sample Location	H_2 Volume %	N_2 Volume %	O_2 Volume %	CO Volume %	CO_2 Volume %	CH_4 Volume %	Total Volume %	Lower Explosive Limit %
Hopper Fume Exhaust Main	3.86	72.99	17.15	2.49	1.12	0.1	97.61	114
Hopper Vertical Fume Uptake	14.29	62.86	3.37	10.20	5.78	0.18	96.68	433
Steam Exhaust Main	0	79	21	0	0	0	100.0	0

SECTION IV-B - ENVIRONMENTAL TESTING

An environmental testing program was conducted in order to quantify the degree of control attributable to the Weirton Steel Division enclosed coke pushing emissions control system. Due to the many problems which have limited the operation of the system, an abbreviated test evaluation was organized to insure the completion of this effort. Safety considerations documented earlier in this report required that the testing program be performed during the pushing of coke from ovens which were in good operating condition with no extraordinary heating problems that would cause excessive gaseous emissions. This requirement seriously hampered the completion of this task since approximately forty percent of the ovens did not qualify for inclusion in the test program. The test program was completed in October 1980 and resulted in a limited data base which indicated that the pushing emissions control system is capable of compliance when utilized in conjunction with ovens in good operating condition.

Description of Test Program

Prior to the initiation of the program, a test protocol was developed and submitted to the Environmental Protection Agency Region III Office for approval. A copy of the approved test protocol is contained in Appendix I. The test method detailed the variations from EPA Methods 1 through 5 for the site restrictions present in the pushing emissions control system. A site located just downstream from the stack silencer and adjacent to a bend in the stack was selected as being the most representative point in the system (see Figure 8). Preliminary traverses of the site indicated a severe velocity dropoff near the center of the stack (Bi-Modal flow) with a fairly uniform profile existing on either side. After discussions with the Environmental Protection Agency represent-

Description of Test Program (cont'd.)

atives, it was agreed that instead of sampling at each traverse point, the sampling probe would be located at the point of highest velocity. This would, in fact, bias the results on the high side. Due to low operability of the quencher system and the low number of "good" ovens available during a given day, it was decided to limit a test run to twelve pushes using two sampling trains. Each train would be used to sample the gas cleaning system, and the results would be added to determine the average stack concentration and loading for that run. This, again, was done to prevent loss of an entire day's test due to an apparent malfunction near the completion of the run.

Figure 19 indicates the general arrangement of the sampling train. The equipment used was an Acurex-Aerotherm Hi-Volume Sampling System. This equipment allowed sufficent sample volume (2 actual cubic feet) per push to be sampled. The total sample time included from the start of a push until the entrance to the quench station. This time varied somewhat depending on the location of the oven and distance to the quench station.

Stack gas samples were also obtained according to EPA Method 3 to determine the molecular weight of the effluent. The samples were analyzed with a gas chromatograph for oxygen, carbon monoxide, carbon dioxide and nitrogen content. These results were then used to compute the stack gas molecular weight.

Pressure drop readings, obtained utilizing a U-tube Manometer and pressure taps located upstream and downstream of the scrubber, were recorded during the pushing operation. Prior to testing, the venturi scrubber was modified to permit manual positioning of the variable throat at desired pressure drops. The test program consisted of three individual tests with each representing a different pressure drop. This was done in order to determine the point at which pressure drop

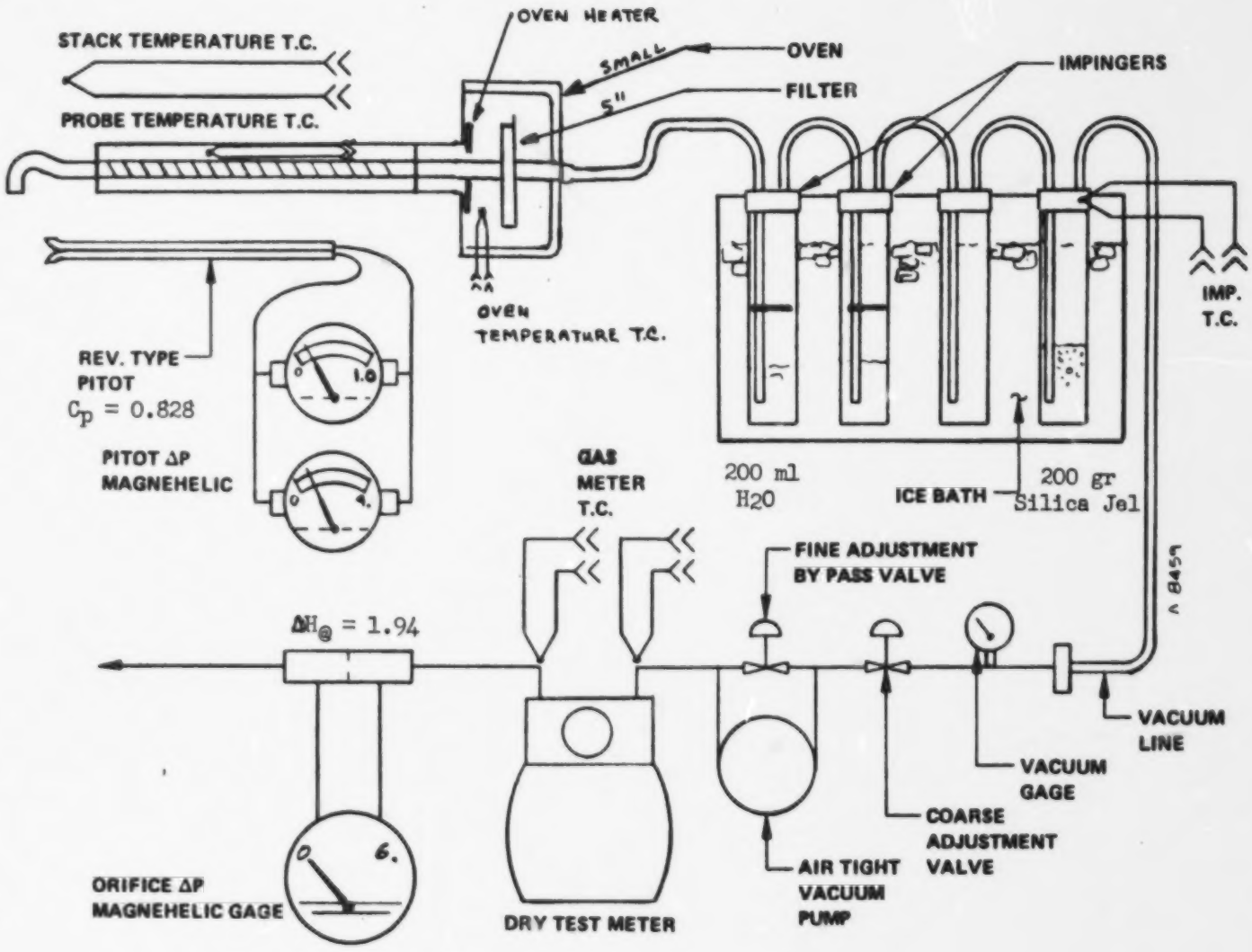


Figure 19
GENERAL ARRANGEMENT OF SAMPLING TRAIN

Description of Test Program (cont'd.)

and volume were optimized to insure good scrubbing efficiency and emission capture.

Results and Conclusions

Table 3 summarizes the results of the individual test runs completed during the stack sampling program. The field data and calculation sheets for these tests are contained in Appendix II. The testing program indicated that the pushing emissions control system is capable of producing an average stack effluent particulate loading of 188 mg/Nm^3 (0.082 grs/scf) on a wet basis, and 224 mg/Nm^3 (0.098 grs/scf) on a dry basis. This level of control complies with applicable coke pushing emissions control regulations. Calculated on a process weight basis, the equivalent loading was 0.018 kg. per metric ton (0.036 lbs/short ton) of coke.

Pressure drops were varied during the testing program with the best quality effluent occurring at 7963 N/m^2 (32 in. H_2O) across the scrubber. The limited data which were generated indicated that a minimum pressure drop of 6719 N/m^2 (27 in. H_2O) is necessary to comply with the applicable standard. Flow rates during this test effort ranged from 673 Nm^3/min. (23,780 scfm) to 1089 Nm^3/min. (38,445 scfm) on a wet basis depending on the pressure drop selected. As indicated in Section IV-A-2 of this report, it has been concluded that these low volume exhaust rates are not adequate to insure the safety of the system and prevent explosions during the pushing of less than well-coked ovens. Efforts to increase the exhaust volume are presently underway with the intent of sufficiently diluting the hydrogen and/or carbon monoxide concentrations below their lower explosive limit. As efforts to increase the system flow rate develop, it will be necessary to establish new pressure

TABLE 3

SUMMARY OF ENCLOSED COKE PUSHING SYSTEM ENVIRONMENTAL TESTING RESULTS

	TEST NO. 1 10/01/80	TEST NO. 2 10/24/80	TEST NO. 3 10/28/80	AVERAGE
I. Scrubber Pressure Drop N/m^2 (in w.c.)	6719 (27)	7963 (32)	4230 (17)	6304 (25.3)
II. Stack Gas Data				
A. Flow				
dscm/min (dscfm)	566 (19,978)	663 (23,419)	910 (32,140)	713 (25,179)
wscm/min (wscfm)	673 (23,780)	766 (27,057)	1089 (38,445)	843 (29,761)
acm /min (acfm)	734 (25,918)	871 (30,753)	1297 (45,788)	967 (34,153)
B. Temperature				
°C (°F)	48.3 (119)	61.1 (142)	72.8 (163)	60.7 (141)
C. Percent Moisture	18.5	16.0	18.9	17.8
D. Composition				
Percent O_2	16.94	16.93	17.55	17.14
Percent CO	0.01	0.04	0.03	0.03
Percent CO_2	4.92	4.58	3.76	4.42
Percent N_2	77.96	78.43	78.64	78.34
III. Particulate Emission Data				
A. Concentration				
mg/dscm (gr/dscf)	272 (0.119)	77 (0.034)	323 (0.141)	224 (0.098)
mg/wscm (gr/wscf)	229 (0.100)	66 (0.029)	270 (0.118)	188 (0.082)
mg/acm (gr/acf)	208 (0.091)	57 (0.025)	229 (0.100)	165 (0.072)
B. Mass				
kg/hr (lbs/hr)	9.24 (20.38)	3.47 (7.64)	21.01 (46.31)	11.24 (24.78)
kg/metric ton (lbs/ton)	0.017(0.033)	0.006 (0.012)	0.031 (0.063)	0.018 (0.036)
kg/push (lbs/push)	0.361(0.795)	0.129 (0.285)	0.688 (1.517)	0.393 (0.866)

drop limits for the scrubber.

SECTION IV-C - ENERGY REQUIREMENTS

Table 4 documents the connected power requirements for various components in the enclosed coke pushing and quenching system. The major energy consumers related to environmental control are the gas cleaning car venturi scrubber and the underground hopper steam-hydro scrubber. These facilities minimize emissions during the pushing, transport and transfer of incandescent coke.

Energy conservation was a major consideration in the design of the gas cleaning car system. High and low modes of gas cleaning capability were provided through the utilization of a variable throat venturi scrubber. Proper utilization of the two modes of operation can achieve a seventy percent reduction in power consumption. A complete description of these facilities is presented in Section III-D of this report.

In order to eliminate the explosive hazard associated with the underground coke hopper exhaust system, the original wet scrubbing facilities, consisting of an orifice washer, cyclone separator and fan, were replaced with a steam-hydro scrubber (see Section III-H). As a result of this installation the energy requirement for the underground coke hopper exhaust was more than doubled. Although this action was not in the best interest of energy conservation, it was considered essential to insure the safety of the facility.

TABLE 4

CONNECTED POWER REQUIREMENTS FOR THE WEIRTON STEEL DIVISION ENCLOSED PUSHING AND QUENCHING SYSTEM

		Kilowatts	(Horsepower)
A. Coke Handling from Oven to Transport Vehicle	1. Door Machine, Coke Guide and Hood		
	a. Traction Drive	44.7	(60)
	b. Hydraulic Pump	18.6	(25)
	c. Door & Jamb Cleaning Device	8.9	(12)
	Sub-Total	72.2	(97)
B. Coke Transport	1. Transfer Car		
	a. Sealing Curtain	5.6	(7.5)
	2. Gas Cleaning Car		
	a. Venturi Scrubber Fan	298.3	(400)
	b. Water Recirculating Pumps	14.9	(20)
	c. Air Compressor	7.5	(10)
	d. Locomotive Traction Drive	128.3	(172)
	Sub-Total	454.6	(609.5)
C. Coke Quenching	*1. Steam-Hydro Scrubber	654	(877)
	2. Quench Steam Induced Draft Fan	93.2	(125)
	**3. Rotary Drum Feeder	18.6	(25)
	**4. Intermediate Conveyor	3.7	(5)
	5. Quench Water Pump	55.9	(75)
	6. Breeze Pumps	29.8	(40)
	7. Control House Air Conditioning & Ventilation	18.6	(25)
	Sub-Total	873.8	(1172)
	TOTAL	1400.6	(1878.5)

*NOTE: - Power equivalent of plant steam consumed by gas scrubbing Calculated as: lb/hr (steam-avg.) x Btu/lb (steam) x 3.929 x 10^{-4} hp-hr/Btu = Equivalent Horsepower.

**NOTE: - Two of the units as indicated would operate concurrently to serve the normal operating requirements.

SECTION IV-C - ENERGY REQUIREMENTS (cont'd.)

Table 5 compares the connected power requirements and the actual energy consumption of the Weirton Steel Division enclosed coke pushing and quenching facilities to conventional (uncontrolled) facilities of an equivalent size. The energy requirements for pollution abatement were derived by taking the difference between the two systems. A review of this table indicates that the total connected power requirement for the enclosed system is more than four times that of a conventional system. The table further indicates that the actual energy consumption for the enclosed system is approximately ten times that of a conventional system. The energy requirements attributed to pollution abatement were 9.13 mJ/t (7900 Btu/ton) for pushing, 27.17 mJ/t (23,500 Btu/ton) for quenching and 36.30 mJ/t (31,400 Btu/ton) for the combined system.

TABLE 5

COMPARISON OF ENERGY REQUIREMENTS FOR THE ENCLOSED COKE PUSHING & QUENCHING SYSTEM VERSUS A CONVENTIONAL SYSTEM

I. Connected Power Requirements	PUSHING kw	PUSHING (b.h.p.)	QUENCHING kw	QUENCHING (b.h.p.)	TOTAL kw	TOTAL (b.h.p.)
A. Weirton Steel Enclosed System	526.8	(706.5)	874.0	(1172)	1400.8	(1878.5)
B. Conventional System	210.3	(282.0)	123.0	(165)	333.3	(447)
C. Difference (Contributable to Pollution Abatement)	316.5	(414.5)	751.0	(1007)	1067.5	(1431.5)

II. Annual Energy Consumption	PUSHING MJ/mt	PUSHING (Btu/ton)	QUENCHING MJ/mt	QUENCHING (Btu/ton)	TOTAL MJ/mt	TOTAL (Btu/ton)
A. Weirton Steel Enclosed System	12.66	(10,900)	27.80	(23,900)	40.46	(34,800)
B. Conventional System	3.53	(3,000)	0.63	(500)	4.16	(3,500)
C. Difference (Contributable to to Pollution Abatement)	9.13	(7,900)	27.17	(23,500)	36.30	(31,300)

SECTION IV-D - CAPITAL AND OPERATING COSTS

A summary of the capital and operating cost for the enclosed coke pushing and quenching system is tabulated in Table 6. The capital cost for the system was $17,300,000 when escalated to 1980 market conditions. This figure includes the cost of the multimillion dollar improvement program which were implemented after the system was installed in 1973. Depreciation cost was calculated utilizing this capital cost and an estimated useful life of fifteen years. The periodic straight line depreciation cost was used, and it was assumed that the probable terminal salvage value was negligible. The projected annual operating cost of this facility is $5,850,000 per year or $6.40 per metric ton ($5.81 per short ton) of coke produced.

The enclosed coke pushing and quenching system was compared to a conventional (uncontrolled) system in order to document the actual cost of pollution abatement. The operating costs for the pushing and quenching facilities for each system were segregated to establish the respective cost trends. Table 7 summarizes the results of this comparison. It can be seen that the operating cost for the coke pushing and transport facilities was increased 26 percent from $1.07 per metric ton ($0.97 per short ton) to $1.35 per metric ton ($1.23 per short ton) of coke. The resulting pollution abatement cost of $0.28 per metric ton ($0.26 per short ton) for coke pushing and transport emission control is significant but tolerable. In contrast, the operating cost for the quenching facilities increased 280 percent from $1.33 per metric ton ($1.21 per short ton) to $5.05 per metric ton ($4.58 per short ton). The resulting pollution abatement cost of $3.72 per metric ton ($3.37 per short ton) is excessive, and this technology cannot be recommended for installation elsewhere since it is con-

sidered cost prohibitive, in the Company's opinion. The operating cost for the combined enclosed coke pushing and quenching system is 167 percent higher than a conventional system resulting in a pollution abatement cost of $4.00 per metric ton ($3.63 per short ton).

TABLE 6

TABULATION OF CAPITAL AND OPERATING COSTS
FOR THE
WEIRTON STEEL ENCLOSED COKE PUSHING AND QUENCHING SYSTEM

A.	Capital (1980 Dollars)	$ 17,300,000
	Life:	15 Years

B. Projected Annual Operating Cost (1980 Dollars):

Cost Description	Annual Operating Cost
Operating Labor	$ 645,000
Repair Labor & Material	3,834,000
Utilities	219,000
Depreciation	1,152,000
TOTAL	$ 5,850,000
Annual Production	
Metric Tons per Year	914,000
(Short Tons per Year)	(1,007,000)
Cost per Unit of Coke Production	
Cost per Metric Ton	$ 6.40
(Cost per Short Ton)	$ (5.81)

TABLE 7

COST COMPARISON
OF THE
ENCLOSED COKE PUSHING AND QUENCHING SYSTEM
TO A CONVENTIONAL (UNCONTROLLED) SYSTEM

	PUSHING & TRANSPORT		COKE QUENCHING		COMBINED TOTAL	
	Cost Per Metric Ton	Cost Per (Short Ton)	Cost Per Metric Ton	Cost Per (Short Ton)	Cost Per Metric Ton	Cost Per (Short Ton)
A. Weirton Steel Enclosed System	$ 1.35	($ 1.23)	$ 5.05	($ 4.58)	$ 6.40	($ 5.81)
B. Conventional System (Uncontrolled)	1.07	(0.97)	1.33	(1.21)	2.40	(2.18)
C. Pollution Abatement (A-B)	0.28	(0.26)	3.72	(3.37)	4.00	(3.63)
D. Percent Increase in Cost $\left(\frac{C}{B} \times 100\right)$	26%		280%		167%	

SECTION V

REFERENCES

1 - Pengidore, D. A., Enclosed Coke Pushing and Quenching System Design Manual; Environmental Protection Agency Technology Series, Publication No. EPA-650/2-73-028, September 1973. (Available for a fee as Publication from the National Technical Information Service (NTIS), Springfield, Virginia)

APPENDIX I

I. Test Protocol for Initial Test of Brown's Island Battery No. 1 Gas Cleaning Car

A. Sampling

(1) Number of Points. A velocity traverse of 12 points on a diameter is taken, and the probe is located at the point of highest velocity (provided this point is not immediately adjacent to the wall; the next highest velocity measurement away from the wall will be used in such a case). This point is sampled for six pushes with one sampling train. A similar procedure is followed for sampling at the remaining port with a new sampling train. A total of twelve pushes constitute one run.

(2) Length of Sampling Time. Sampling is to begin when coke first moves into the hot car (a slight gap exists between the hood and the hot car which is visible to the test team) and ends with the gas cleaning car arrival at the quench station.

(3) Number of Runs. Three runs of twelve pushes each will constitute the compliance test.

(4) Minimum Sampling Volume. A minimum of two actual cubic feet shall be sampled for each point.

(5) Time Requirement for a Run. Each run shall be completed within one day.

B. Calculations

(1) Actual Emissions (Mass/Push). The mass emissions for each run shall be calculated by multiplying the concentration of particulate matter in the sample volume (mass/volume) by the total stack volumetric flow (volume/time) and by the total time spent sampling (time) divided by the number of pushes for that run.

B. Calculations (contd)

(2) Allowable Emissions. The allowable emissions shall be calculated from $E = C^{.09}$ by taking C to be the average tons of coal per charge for all charges within the compliance test.

C. Miscellaneous

(1) Methods 1 through 5 Exceptions. A stainless steel probe, liner and filter holder shall be allowed.

(2) Recording Requirements. The pressure drop on the Venturi shall be recorded during each push.

(3) The following coke ovens on Battery No. 1 are of sufficient heating and refractory conditions such that the greenness of the coke does not present a safety hazard in the existing pushing system: Section A: 26 ovens - 1 through 21, 25 through 29; Section B: 7 ovens - 13, 14, 19, 20, 24, 28 and 29; Section C: 19 ovens - 1 through 14, 18, 19, 24, 25 and 29.

II. Coke Battery Pushing Emissions Control Device Outlet Test Procedure

A. Methodology

The following exceptions to 40 C.F.R. Part 60, Appendix A, Methods 1 through 5, as amended, shall be permitted:

(1) A glass cyclone shall be allowed between the probe and the filter holder.

(2) Acetone shall be allowed as the rinsing agent in performing the washing procedure associated with cleanup which is done after each test.

(3) The requirements of 40 C.F.R. Part 60, Appendix A, Methods 1 through 5 may be modified upon a demonstration to the U.S. EPA and approval by the U.S. EPA that such modifications are equivalent to 40 C.F.R. Part 60, Appendix A, Methods 1 through 5.

TEST NO.: 1

LOCATION: B.I. G.C.C.

Stack Inside Dimensions: 29.75

Stack Area = 4.83 Sq. Ft.

Barometric Pressure: P_b = 29.92 Inches Hg., Stack Gauge

Pressure = 1.0 Inches H_2O

Stack Abs. Pressure: P_s = 1.0 In. $\frac{H_2O}{13.6}$ + Pb = 29.99 Inches Hg.

Stack Gas Temperature: T_s = 119 °F. + 460 = 579 °R.

Molecular Weight of Stack Gas: M_s = 27.30.

Cp = .84 Δp = 2.2

1. $V_s = 174\ Cp \sqrt{\Delta pT} \times \frac{29.92}{P_s} \times \frac{28.96}{M_s}$

   V_s 5366 Feet/Minute

2. Volume = 5366 Feet/Min. x 4.83 Square Ft. = 25,918 Cu.Ft/Min. (H)

   Standard Volume at 70° F. and 29.92 Inches Hg.:

3. Cu.Ft/Min. x $\frac{530}{T_s} \times \frac{P_s}{29.92}$ = 25,918 x $\frac{530}{579}$ x $\frac{29.99}{29.92}$ = 23,780 scfm(G)

DATA RECORDER: G. Doak

DATE: 10/01/80

TEST NO.: 2

LOCATION: B.I. G.C.C.

Stack Inside Dimensions: 29.75

Stack Area = 4.83 Sq. Ft.

Barometric Pressure: P_b = 29.83 Inches Hg., Stack Gauge

Pressure = 1.0 Inches H_2O

Stack Abs. Pressure: P_s = 1.0 In. $\frac{H_2O}{13.6}$ + Pb = 29.9 Inches Hg.

Stack Gas Temperature: T_s = 142 °F. + 460 = 602 °R.

Molecular Weight of Stack Gas: M_s = 27.58 .

Cp = .84 Δp = 3.0

1. $V_s = 174\ Cp \sqrt{\Delta pT} \times \frac{29.92}{P_s} \times \frac{28.96}{M_s}$

   V_s 6367 Feet/Minute

2. Volume = 6377 Feet/Min. x 4.83 Square Ft. = 30,753 Cu.Ft/Min. (H)

   Standard Volume at 70° F. and 29.92 Inches Hg.:

3. Cu.Ft/Min. x $\frac{530}{T_s} \times \frac{P_s}{29.92}$ = 30,753 x $\frac{530}{602}$ x $\frac{29.9}{29.92}$ = 27,057 scfm(G)

DATA RECORDER: G. Doak

DATE: 10/24/80

TEST NO.: 3

LOCATION: B.I. G.C.C.

Stack Inside Dimensions: 29.75

Stack Area = 4.83 Sq. Ft.

Barometric Pressure: P_b = 29.46 Inches Hg., Stack Gauge

Pressure = 1.0 Inches H_2O

Stack Abs. Pressure: P_S = 1.0 In. $\frac{H_2O}{13.6}$ + Pb = 29.53 Inches Hg.

Stack Gas Temperature: T_S = 163 °F. + 460 = 623 °R.

Molecular Weight of Stack Gas: M_S = 27.16.

Cp = .84 Δp = 6.25

1. $V_S = 174\ Cp \sqrt{\Delta pT} \times \frac{29.92}{P_S} \times \frac{28.96}{M_S}$

   V_S 9480 Feet/Minute

2. Volume = 9480 Feet/Min. x 4.83 Square Ft. = 45,788 Cu.Ft/Min. (H)

   Standard Volume at 70° F. and 29.92 Inches Hg.:

3. Cu.Ft/Min. x $\frac{530}{T_S} \times \frac{P_S}{29.92}$ = 45,788 x 530 x $\frac{29.9}{29.92}$ = 38,445 scfm (G)

DATA RECORDER: G. Doak

DATE: 10/28/80

WEIGHT OF PARTICULATE COLLECTED

Field Container Number	Total Final Weight (mg)	Tare Weight (mg)	Weight Gain (mg)
Filter		____ Filter ____ Container	
Probe and Cyclone			
Impinger Organics			
Water Solubles			
Acetone Washings			

Plant Coke Plant
Run No. 1
Location B.I. G.C.C.
Received from ___ by ___
Analyzer Horvath
Date Analyzed 10/01/80

TOTAL WEIGHT OF PARTICULATES COLLECTED, W_p = x 2.2×10^{-6} = Lbs.
x 15.4×10^{-3} = Grs.

VOLUME OF MOISTURE COLLECTED

	Final Volume, ml	Initial Volume or Weight	Volumetric Gain, (ml)
Impingers	197 + 198 + 171	400 ml	166
Silica Gel Container			6.2

TOTAL VOLUME OF WATER COLLECTED, V_T = 172.2 ml x 0.047 = 8.09 SCF

WEIGHT OF PARTICULATE COLLECTED

Field Container Number	Total Final Weight (mg)	Tare Weight (mg)	Weight Gain (mg)
Filter		____ Filter ____ Container	
Probe and Cyclone			
Impinger Organics			
Water Solubles			
Acetone Washings			

Plant Coke Plant
Run No. 2
Location B.I. G.C.C.
Received from ___ by ___
Analyzer Doak and Horvath
Date Analyzed 10/24/80

TOTAL WEIGHT OF PARTICULATES COLLECTED, w_p = x 2.2×10^{-6} = Lbs.
x 15.4×10^{-3} = Grs.

VOLUME OF MOISTURE COLLECTED

	Final Volume, ml	Initial Volume or Weight	Volumetric Gain, (ml)
Impingers	159 + 200 + 200	400 ml	159
Silica Gel Container			27.1

TOTAL VOLUME OF WATER COLLECTED, V_T - 186.1 ml x 0.047 = 8.75 SCF

WEIGHT OF PARTICULATE COLLECTED

Field Container Number	Total Final Weight (mg)	Tare Weight (mg)	Weight Gain (mg)
Filter		____ Filter ____ Container	
Probe and Cyclone			
Impinger Organics			
Water Solubles			
Acetone Washings			

Plant Coke Plant
Run No. 3
Location B.I. G.C.C.
Received from ____ by ____
Analyzer Doak and Horvath
Date Analyzed 10/28/80

TOTAL WEIGHT OF PARTICULATES COLLECTED, w_p = x 2.2×10^{-6} = Lbs.
x 15.4×10^{-3} = Grs.

VOLUME OF MOISTURE COLLECTED

	Final Volume, ml	Initial Volume or Weight	Volumetric Gain, (ml)
Impingers	254 + 198 + 196	400 ml.	248
Silica Gel Container			24.3

TOTAL VOLUME OF WATER COLLECTED, V_T = 272.3 ml x 0.047 = 12.8 SCF

VENTURI SCRUBBER PRESSURE DROP

(Inches of Water)

Oven No.	Test No. 1	Test No. 2	Test No. 3
1	28	32	14
2	27	34	19
3	26	33	20
4	27	31	18
5	28	31	18
6	28	35	16
7	26	32	14
8	26	31	12
9	26	32	15
10	26	35	17
11	28	31	19
12		30	
AVERAGE	27	32	17

TEST NO. 1

MAXIMUM VELOCITY POINT DETERMINATION

	Position Inches[a]	Reading, Δp Inches H_2O	$\sqrt{\Delta p}$	T_s, °F
	South Port			
1	.625	1.6		
2	1.993	2.3		
3	3.511	2.4		
4	5.266	1.6		
5	7.438	0.6		
6	10.591	0.3		
7	19.159	0.4		
8	22.313	1.0		
9	24.484	1.9		
10	26.240	2.0		
11	27.757	1.7		
12	29.125	1.4		
	East Port			
1	.625	2.2		
2	1.993	2.1		
3	3.511	2.4		
4	5.266	1.9		
5	7.438	1.4		
6	10.591	0.7		
7	19.159	0.3		
8	22.313	1.0		
9	24.484	1.2		
10	26.240	1.1		
11	27.757	0.9		
12	29.125	0.6		

a. Measured distance from opposing wall

TEST NO. 2

MAXIMUM VELOCITY POINT DETERMINATION

Position Inches	Reading, Δp Inches H_2O	$\sqrt{\Delta p}$	T_s, °F
South Port			
1	3.0		134
2	4.0		134
3	4.2		134
4	3.5		134
5	2.3		134
6	0.7		134
7	1.0		134
8	2.4		134
9	3.2		134
10	3.2		134
11	2.4		134
12	1.8		134
East Port			
1	3.2		132
2	4.2		132
3	4.2		135
4	3.2		136
5	4.0		137
6	1.5		137
7	1.4		139
8	2.2		140
9	1.7		140
10	1.8		140
11	1.2		138
12	1.0		135

TEST NO. 3

MAXIMUM VELOCITY POINT DETERMINATION

Position Inches	Reading, Δp Inches H_2O	$\sqrt{\Delta p}$	T_s, °F
South Port			
1	5.8		125
2	5.8		
3	7.0		
4	4.4		
5	2.2		
6	0.8		
7	0.6		
8	1.6		
9	4.0		
10	4.4		
11	4.2		
12	4.2		
East Port			
1	4.2		125
2	4.6		
3	6.2		
4	6.0		
5	4.8		
6	0.8		
7	0.4		
8	2.4		
9	3.6		
10	3.2		
11	3.4		
12	3.6		

APPENDIX II
WEIRTON STEEL DIVISION - ENVIRONMENTAL CONTROL DEPARTMENT
CALCULATION SHEET

SOURCE NAME: Particulate FILTER NO.: 1A and 2A
LOCATION: B.I. Gas Car METER BOX NO.: 1 Unit
TYPE OF SOURCE: Coke Plt Battery Push METER Δ H At : .211
RUN NO.: 1 Cp FACTOR: .84 METER FACTOR: 1.08

A-Weight of Particulate on Filter, gm	.30087
B-Weight of Probe Washing, gm	.02860
C-Total Weight of Particulate and Washing, gm	.32947
D-Weight of Residue in Acetone Blank, gm	-
E-Total Weight of Particulate, gm	.32947
F-Dry Gas Meter _____ x Meter Factor _____, CF	43.489
G-Stack Gas Flow Rate (Wet Basis) SCFM	23,780
H-Actual Stack Gas Flow Rate, CFM	25,918
I-Condensate in Impingers, ml	166.0
J-Weight Gain in Silica Gel, ml	6.2
K-Total Volume of Captured Water, ml	172.2
L-Orsat Analyses: CO_2 4.92 %; O_2 16.94 %; CO .01 %; N_2	77.96 %
M-Molecular Weight of Dry Gas, Lbm/Lb - Mole	29.41
*N-Molecular Weight of Wet Gas, Lbm/Lb - Mole	27.30
O-Barometric Pressure, In. Hg. (Pbar)	29.92
P-Temperature of Meter Tm, F°	80

Q-Pressure at Meter, Pm = Pbar + (ΔH/13.6) = 30.00 In. Hg.
R-Dry Volume Sampled, 17.71 x F x Q/(460 + P = 42.788 DSCF
S-Moisture Content [(Kx0.0474)/(Kx0.0474 + R) x .025] x 100 = 18.5 %
*T-Molecular Wt. of Wet Gas, N=[1-(.01xS)]xM+(.18xS) = 27.30 Lbm/Lb Mole
U-Concentration (Ex 1000)/(R x .0283) = 272.1 Mg/Cu.M. Dry
V-Concentration, 15.43 x E/R = 0.1188 Grains SCF Dry
W-Condensate Vapor Volume, 0.00267 x K x (460 + P)/Q = 8.276 CF
Y-Total Volume Sampled, F + W = 51.765 CF
Z-Sample Volume, 17.71 x Y x Q (460 + P) = 50.931 SCF (Wet)
AA-Concentration 15.43 x E/Z = 0.100 Grains/SCF (Wet)

.100 Grains/SCF (23,780 SCF/Min) (25.75 Min) (Lb.) = .795 Lbs/Push
(11 Pushes) (7000 Grs)

BB-Material Flow Rate 60 x AA x G/7000 = _____ Lbs/Hr.
CC-Percent Isokinetic

Stack Area: = 4.83 Sq. Feet
Dia. Nozzle: = .250 Inches
Time θ: = 25.75 Minutes

I = 57,600 (Stack Area) R/G θ (Dia. Noz) ^{2} = 99.0 %

DATA RECORDER: G. Doak
DATE: 10/01/80

* - Used "T" to calculate "N"

APPENDIX II
WEIRTON STEEL DIVISION - ENVIRONMENTAL CONTROL DEPARTMENT
CALCULATION SHEET

SOURCE NAME: B.I. Coke Plant FILTER NO.: 3A and 5A
LOCATION: B.I. Gas Car METER BOX NO.: 1
TYPE OF SOURCE: CP Battery Pushing METER Δ H At : .211
RUN NO.: 2 Cp FACTOR: .84 METER FACTOR: 1.08

A-Weight of Particulate on Filter, gm	.11909
B-Weight of Probe Washing, gm	.00520
C-Total Weight of Particulate and Washing, gm	.12429
D-Weight of Residue in Acetone Blank, gm	-
E-Total Weight of Particulate, gm	.12429
F-Dry Gas Meter 51.833 x Meter Factor 1.08 , CF	55.980
G-Stack Gas Flow Rate (Wet Basis) SCFM	27,057
H-Actual Stack Gas Flow Rate, CFM	30,753
I-Condensate in Impingers, ml	159
J-Weight Gain in Silica Gel, ml	27.1
K-Total Volume of Captured Water, ml	186.1
L-Orsat Analyses: CO_2 4.58 %; O_2 16.93 %; CO 0.04 %; N_2	78.43 %
M-Molecular Weight of Dry Gas, Lbm/Lb - Mole	29.41
*N-Molecular Weight of Wet Gas, Lbm/Lb - Mole	27.58
O-Barometric Pressure, In. Hg. (Pbar)	29.83
P-Temperature of Meter Tm, F°	64

Q-Pressure at Meter, Pm = Pbar + (ΔH/13.6) = 29.94 in Hg.
R-Dry Volume Sampled, 17.71 x F x Q/(460 + P = 56.646 DSCF
S-Moisture Content [(Kx0.0474)/(Kx0.0474 + R) x .025] x 100 = 16.0 %
*T-Molecular Wt. of Wet Gas, N=[1-(.01xS)]xM+(.18xS) = 27.58 Lbm/Lb Mole
U-Concentration (Ex 1000)/(R x .0283) = 77.536 Mg/Cu.M. Dry
V-Concentration, 15.43 x E/R = .034 Grains SCF Dry
W-Condensate Vapor Volume, 0.00267 x K x (460 + P)/Q = 8.696 CF
Y-Total Volume Sampled, F + W = 64.676 CF
Z-Sample Volume, 17.71 x Y x Q (460 + P) = 65.446 SCF (Wet)
AA-Concentration 15.43 x E/Z = 0.029 Grains/SCF (Wet)
.029 Grains/SCF (27,057 SCF/Min) (30.5 Min) (1 lbs) = 0.285 Lbs/Push
(12 Pushes) (7000 Grs)
BB-Material Flow Rate 60 x AA x G/7000 = _____ Lbs/Hr.
CC-Percent Isokinetic

Stack Area: = 4.83 Sq. Feet
Dia. Nozzle: = .250 Inches
Time θ: = 30.5 Minutes

I = 57,600 (Stack Area) R/G θ (Dia. Noz) ^{2} = 97.3 %

* - Used "T" to calculate "N"

DATA RECORDER: Gary Doak
DATE: 10/24/80

APPENDIX II
WEIRTON STEEL DIVISION - ENVIRONMENTAL CONTROL DEPARTMENT.
CALCULATION SHEET

SOURCE NAME: Gas Cleaning Car FILTER NO.: 4A
LOCATION: B.I. Battery METER BOX NO.: 1
TYPE OF SOURCE: Particulate METER Δ H At : .211
RUN NO.: 3 Cp FACTOR: .84 METER FACTOR: 1.08

A-Weight of Particulate on Filter, gm	.56761
B-Weight of Probe Washing, gm	.03099
C-Total Weight of Particulate and Washing, gm	.59860
D-Weight of Residue in Acetone Blank, gm	-
E-Total Weight of Particulate, gm	.59860
F-Dry Gas Meter 60.795 x Meter Factor 1.08 , CF	65.659
G-Stack Gas Flow Rate (Wet Basis) SCFM	38,445
H-Actual Stack Gas Flow Rate, CFM	45,788
I-Condensate in Impingers, ml	248
J-Weight Gain in Silica Gel, ml	24.3
K-Total Volume of Captured Water, ml	272.3
L-Orsat Analyses: CO_2 3.76 %; O_2 17.55 %; CO .03 %; N_2	78.64 %
M-Molecular Weight of Dry Gas, Lbm/Lb - Mole	29.30
*N-Molecular Weight of Wet Gas, Lbm/Lb - Mole	27.16
O-Barometric Pressure, In. Hg. (Pbar)	29.46
P-Temperature of Meter Tm, F°	66

Q-Pressure at Meter, Pm = Pbar + (ΔH/13.6) = 29.68 in Hg.
R-Dry Volume Sampled, 17.71 x F x Q/(460 + P = 65.13 DSCF
S-Moisture Content [(Kx0.0474)/(Kx0.0474 + R) x .025] x 100 = 18.9 %
*T-Molecular Wt. of Wet Gas, N=[1-(.01xS)]xM+(.18xS) = 27.16 Lbm/Lb Mole
U-Concentration (Ex 1000)/(R x .0283) = 322.3 Mg/Cu.M. Dry
V-Concentration, 15.43 x E/R = .141 Grains SCF Dry
W-Condensate Vapor Volume, 0.00267 x K x (460 + P)/Q = 12.88 CF
Y-Total Volume Sampled, F + W = 78.539 CF
Z-Sample Volume, 17.71 x Y x Q (460 + P) = 78.484 SCF (Wet)
AA-Concentration 15.43 x E/Z = .118 Grains/SCF (Wet)

.118 Grains/SCF (38,445 SCF/Min) (25.75 Min) / (11 Pushes) (1 lbs / 7000 Grs) = 1.517 Lbs/Push

BB-Material Flow Rate 60 x AA x G/7000 = _____ Lbs/Hr.
CC-Percent Isokinetic

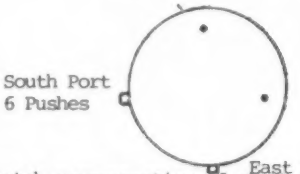
Stack Area: = 4.83 Sq. Feet
Dia. Nozzle: = .250 Inches
Time θ: = 25.75 Minutes

I = 57,600 (Stack Area) R/G θ (Dia. Noz) ^{2} = 93.9 %

DATA RECORDER: G. Doak
* - Used "T" to calculate "N"
DATE: 10/28/80

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 1
Date: 10/01/80
Operator: Horvath
Filter No.: 1A
Meter Box No.: 1
Meter ΔH_C: .211
C Factor: .84

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET



(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F : 60°
Barometric Pressure In . Hg. 29.9
Assumed Moisture % 5
Heater Box Setting °F 250
Nozzle Diameter, Inche 1/4
Probe Length 3 Ft.
Probe Heater Setting 250
Avg. Δp 2.2 Avg. ΔH 1.083
Avg. T_m 80 Avg. T_s 119
Avg. P_s _____ Avg Vel.fps 89.4

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 Of	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
B-20	0	961.637	3.3	1.6	1.6	4.0		111					
	30		2.2	1.1	1.1	4.0		130					
	60		2.7	1.3	1.3	3.5		120					
	90		2.8	1.4	1.4	3.5		122					
	120		2.8	1.4	1.4	3.0		122					
	150								228	65	225	65	65
B-24	0	965.952	3.3	1.6	1.6	3.5		126					
	30		2.5	1.2	1.2	3.0		130					
	60		2.5	1.2	1.2	3.0		131					
	90		2.5	1.2	1.2	3.0		130					
	120		2.7	1.3	1.3	3.0		130					
	150								235	67	200	70	69
C-24	0	969.964	2.8	1.4	1.4	2.5		135					
	30		2.2	1.1	1.1	2.0		140					
	60		2.2	1.1	1.1	2.0		140					
	90		2.2	1.1	1.1	3.0		129					
	120								229	69	210	73	72
B-28	0	973.010	3.1	1.5	1.5	4.0		102					
	30		2.2	1.1	1.1	3.0		131					

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 1
Date: 10/01/80
Operator: Horvath
Filter No.: 1A & 3A
Meter Box No.:
Meter ΔH_C:
C Factor:

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F :
Barometric Pressure In. Hg.
Assumed Moisture %
Heater Box Setting Of °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp ____ Avg. ΔH ____
Avg. T_m ____ Avg. T_s ____
Avg. P_s ____ Avg Vel.fps ____

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 Of	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
B-28(cont)	60		2.2	1.1	1.1	3.0		134					
	90		2.2	1.1	1.1	3.0		132					
	120		2.2	1.1	1.1	2.5		130					
	135								233	68	269	75	74
A-1	0	976.992	3.1	1.5	1.5	3.0		141					
	30		2.2	1.1	1.1	2.5		163					
	60		2.2	1.1	1.1	2.5		165					
	90		2.2	1.1	1.1	2.5		152					
	120		2.2	1.1	1.1	2.5		148					
	150		2.2	1.1	1.1	2.5		147					
	180								233	81	209	81	80
C-1	0	981.937	2.5	1.2	1.2	2.5		147					
	30		2.1	1.0	1.0	2.5		154					
	60		2.1	1.0	1.0	2.5		158					
	90		2.1	1.0	1.0	2.0		154					
	120		1.7	0.8	0.8	2.0		153					
	135	985.547							234	85	212	83	83
C-3	0	987.162	2.3	1.1	1.1	15.0		85					
	30		2.3	1.1	1.1	15.0		86					

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 1
Date: 10/01/80
Operator: Horvath
Filter No.: 2A
Meter Box No.: _____
Meter ΔH_C: _____
C Factor: _____

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F: _____
Barometric Pressure In. Hg. _____
Assumed Moisture % _____
Heater Box Setting Of °F _____
Nozzle Diameter, Inches _____
Probe Length _____
Probe Heater Setting _____
Avg. Δp _____ Avg. ΔH _____
Avg. T_m _____ Avg. T_s _____
Avg. P_s _____ Avg Vel.fps _____

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 Of	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
C-3(cont)	60		2.3	1.1	1.1	10.0		87					
	90		2.3	1.1	1.1	3.0		88					
	120		2.3	1.1	1.1	3.0		87					
	135	990.963							230	84	212	85	86
C-9	0		2.1	1.0	1.0	3.0		90					
	30		2.1	1.0	1.0	3.0		91					
	60		1.6	0.8	1.0	2.0		91					
	90		1.6	0.8	0.8	2.0		91					
	120	993.707							233	84	210	87	87
A-11	0		1.7	0.8	0.8	2.0		99					
	30		1.7	0.8	0.8	2.0		98					
	60		1.7	0.8	0.8	2.0		100					
	90		1.7	0.8	0.8	2.0		101					
	100		1.7	0.8	0.8	2.0		101					
	150								231	84	210	88	88
A-13	0	997.035	1.8	0.7	0.7	2.0		101					
	30		1.8	0.7	0.7	2.0		101					
	60		1.2	0.6	0.6	3.0		101					
	90		1.2	0.6	0.6	3.0		102					

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 1
Date: 10/01/80
Operator:
Filter No.: 2A
Meter Box No.:
Meter ΔH_C:
C Factor:

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F:
Barometric Pressure In. Hg.
Assumed Moisture %
Heater Box Setting Of °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp ____ Avg. ΔH
Avg. T_m ____ Avg. T_s
Avg. P_s ____ Avg Vel.fps

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 Of	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
B-13(cont)	120												
B-13	0	999.625	2.5	1.2	1.2	3.0		102	231	-	212	89	84
C-13	30	003.520	2.2	1.1	1.1	3.0		100					
	60		2.2	1.1	1.1	3.0		99					
	90		2.2	1.1	1.1	3.0		98					
	120		2.2	1.1	1.1	3.0		99					
	150								231		211	90	89

Source Name: B.I. Gas Cleaning Car
Location:
Type of Source: Particulate
Run Number: 2
Date: 10/24/80
Operator: Horvath
Filter No.: 3A
Meter Box No.: 1
Meter ΔH_C:
C Factor: .84

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

EAST PORT

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F: 50°
Barometric Pressure In. Hg. 29.83
Assumed Moisture % 15
Heater Box Setting - °F 250
Nozzle Diameter, Inches 1/4"
Probe Length 3 Ft.
Probe Heater Setting 250°
Avg. Δp 3.0 Avg. ΔH 1.465
Avg. T_m 64.25 Avg. T_s 14.2
Avg. P_s _____ Avg Vel.fps 106

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & 64 In.H_2O Δp	Orifice ΔH In. H_2O Desired	Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	6 Outlet
A-8	0	004.434	3.6	1.7				110					
	30		3.6	1.7		6.0		124					
	60		3.0	1.5		5.0		105					
	90		3.0	1.5		5.0		129					
	120		3.0	1.5		5.0		132					
	150		3.0	1.5		5.0		123					
	180	008.722							248	58	2.07	57	56
C-4	0		4.2	2.0		5.0		117					
	30		3.0	1.5		5.0		140					
	60		3.0	1.5		5.0		139					
	90		3.0	1.5		5.0		141					
	120		3.2	1.6		5.0		142					
	150	013.223							251	63	208	60	58
C-6	0		3.7	1.8		5.0		124					
	30		3.0	1.5		5.0		141					
	60		3.0	1.5		5.0		142					
	90		3.3	1.6		5.0		143					
	120		3.3	1.6		5.0		145					
	150	017.726							249	63	257	61	60

Source Name: B.I. Gas Cleaning Car
Location:
Type of Source: Particulate
Run Number: 2
Date: 10/24/80
Operator: Horvath
Filter No.: 3A
Meter Box No.: 1
Meter ΔH_C:
C Factor: .84

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

EAST PORT

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F:
Barometric Pressure In. Hg.
Assumed Moisture %
Heater Box Setting - °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp ____ Avg. ΔH
Avg. T_m ____ Avg. T_s
Avg. P_s ____ Avg Vel.fps

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot Δp In.H_2O	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
A-10	0		3.7	1.8		4.5		133					
	30		3.0	1.5		4.5		149					
	60		3.0	1.5		4.5		148					
	90		3.0	1.5		4.5		148					
	120		3.0	1.5		5.0		151					
	150		3.0	1.5		5.0		153					
	180	023.054							252	66	208	64	62
A-12	0		3.5	1.7		4.8		133					
	30		3.0	1.5		4.5		151					
	60		3.0	1.5		4.5		151					
	90		3.0	1.5		4.5		151					
	120		3.0	1.5		4.5		152					
	150		3.0	1.5		5.0		153					
	180	028.393							251	67	208	65	64
C-10	0		3.5	1.7		3.5		140					
	30		2.7	1.3		3.0		150					
	60		3.0	1.5		3.5		145					
	90		3.0	1.5		3.5		144					
	120	031.924							251	60	255	64	63

Source Name: B.I. Gas Cleaning Car
Location:
Type of Source: Particulate
Run Number: 2
Date: 10/24/80
Operator: Horvath
Filter No.: 5A
Meter Box No.:
Meter ΔH_C:
C Factor: 55.2

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

SOUTH PORT

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F:
Barometric Pressure In. Hg.
Assumed Moisture %
Heater Box Setting - °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp ____ Avg. ΔH
Avg. T_m ____ Avg. T_s
Avg. P_s ____ Avg Vel. fps

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
C-12	0	031.924	3.5	1.7		3.0		127					
	30		3.5	1.7		2.0		129					
	60		2.7	1.3		3.0		139					
	90		2.7	1.3		3.0		134					
	120		2.7	1.3		3.0		130					
	150	036.192							251	62	203	66	65
C-14	0		3.5	1.7		3.5		147					
	30		3.0	1.5		3.0		161					
	60		3.0	1.5		3.8		158					
	90		3.0	1.5		4.0		157					
	120	039.784							252	56	207	68	66
B-14	0		3.7	1.8		4.0		135					
	30		2.7	1.3		3.0		141					
	60		2.7	1.3		3.0		136					
	90		2.7	1.3		3.0		135					
	120		2.7	1.3		3.0		135					
	150	044.000							248	63	208	71	69
B-20	0		3.5	1.7		4.0		142					
	30		2.3	1.1		3.0		148					

Source Name: B.I. Gas Cleaning Car
Location:
Type of Source: Particulate
Run Number: 2
Date: 10/24/80
Operator: Horvath
Filter No.: 5A
Meter Box No.:
Meter ΔHc:
C Factor: 29.1

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

SOUTH PORT

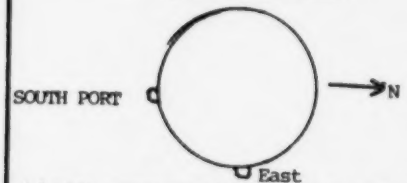
(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F :
Barometric Pressure In Hg.
Assumed Moisture %
Heater Box Setting - °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp Avg. ΔH
Avg. T_m Avg. T_s
Avg. P_s Avg Vel.fps

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot Δp In.H_2O	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
B-20(cont)	60		2.3	1.1		3.0		147					
	90		2.3	1.1		3.0		146					
	120		2.7	1.3		3.0		147					
	135	047.743											
A-14	0		3.3	1.6		4.0		143					
	30		2.5	1.2		3.0		138					
	60		2.5	1.2		3.0		138					
	90		2.5	1.2		3.0		136					
	120		2.5	1.2		3.0		138					
	150	051.845							252	67	209	74	72
A-18	0		3.3	1.6		3.5		147					
	30		2.5	1.2		3.5		159					
	60		2.5	1.2		3.5		155					
	90		2.5	1.2		3.5		155					
	100		2.5	1.2		3.5		158					
	150		2.5	1.2		3.0		160					
	165	056.267											

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 3
Date: 10/28/80
Operator: Horvath
Filter No.: 2
Meter Box No.: 1
Meter ΔH_C:
C Factor:

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET



(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F: 50°
Barometric Pressure In. Hg. 29.46
Assumed Moisture % 15
Heater Box Setting - °F 250
Nozzle Diameter, Inches 1/4
Probe Length 3 Ft.
Probe Heater Setting 250
Avg. Δp 6.25 Avg. ΔH 3.039
Avg. T_m 66.182 Avg. T_s 163
Avg. P_s _____ Avg Vel.fps 158

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
C-5	0	056.472	8.2	4.0		8.0		108					
	30		6.8	3.4		7.0		128					
	60		6.8	3.4		7.0		122					
	90		6.8	3.4		6.5		124					
	120		6.8	3.4		6.5		125					
	135	062.993							225	59	240	59	59
C-7	0		7.4	3.6		7.0		126					
	30		6.2	3.0		7.0		141					
	60		6.8	3.4		7.0		136					
	90		6.8	3.4		7.0		137					
	120		6.8	3.4		7.0		138					
	135	067.557							224	62	241	61	61
C-11	0		7.4	3.6		6.5		134					
	30		6.4	3.2		6.0		142					
	60		6.4	3.2		6.0		135					
	90		7.0	3.4		7.0		136					
	120	072.395							224	64	241	63	63
C-13	0		7.4	3.6		7.0		134					
	30		6.2	3.0		6.0		153					

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 3
Date: 10/28/80
Operator: Horvath
Filter No.: 2 & 3
Meter Box No.: 1
Meter ΔH_C:
C Factor:

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F:
Barometric Pressure In. Hg.
Assumed Moisture %
Heater Box Setting °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp Avg. ΔH
Avg. T_m Avg. T_s
Avg. P_s Avg Vel.fps

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
C-13(cont)	60		6.2	3.0		6.5		143					
	90		6.8	3.4		6.5		142					
	120	077.349							225	64	241	64	63
A-9	0		7.4	3.6		6.0		139					
	30		6.6	3.2		7.0		154					
	60		6.6	3.2		7.0		142					
	90		7.0	3.4		7.5		144					
	120		7.0	3.4		8.0		145					
	150		7.0	3.4		8.0		145					
	165	084.645							224	67	241	65	64
A-15	0		8.0	3.8		8.0		142					
	30		8.0	3.8		8.0		177					
	60		5.2	2.5		12.0		178					
	90		6.2	3.0		14.0		178					
	120		6.2	3.0		14.0		177					
	150		6.2	3.0		13.5		176					
	165	091.542							235	69	241	67	67
B-13	0		5.2	2.5		6.0		166					
	30		5.2	2.5		8.0		172					

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 3
Date: 10/28/80
Operator: Horvath
Filter No.:
Meter Box No.:
Meter ΔH_C:
C Factor:

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F:
Barometric Pressure In. Hg.
Assumed Moisture %
Heater Box Setting - °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp ____ Avg. ΔH
Avg. T_m ____ Avg. T_s
Avg. P_s ____ Avg Vel.fps

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot Δp In.H_2O	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
B-13 (cont	60		5.0	2.4		11.0		367					
	90		5.0	2.4		11.0		303					
	120		4.0	2.0		11.0		390					
	150	096.774											
A-17	0		6.2	3.0		9.0		143	235	69	238	69	68
	30		5.9	2.8		8.0		144					
	60		5.9	2.8		8.0		143					
	90		5.9	2.8		8.0		144					
	120	101.401											
A-19	0		6.2	3.0		8.5		152	239	72	241	70	69
	30		5.4	2.6		7.5		161					
	60		5.4	2.6		7.5		157					
	90		5.4	2.6		7.5		158					
	120		5.4	2.6		8.0		161					
	150	106.777											
B-19	0		6.2	3.0		9.0		156	237	71	241	70	70
	30		5.4	2.6		8.5		168					
	60		5.8	2.8		8.5		163					
	90		5.8	2.8		9.0		164					

Source Name: Brown's Island
Location: Gas Cleaning Car
Type of Source: Particulate
Run Number: 3
Date: 10/28/80
Operator: Horvath
Filter No.:
Meter Box No.:
Meter ΔH_C:
C Factor:

WEIRTON STEEL ENVIRONMENTAL CONTROL
EMISSION CONTROL SECTION
FIELD DATA SHEET

(Sketch cross-section of stack and plot sampling points here)

Ambient Temperature °F:
Barometric Pressure In. Hg.
Assumed Moisture %
Heater Box Setting - °F
Nozzle Diameter, Inches
Probe Length
Probe Heater Setting
Avg. Δp ____ Avg. ΔH
Avg. T_m ____ Avg. T_s
Avg. P_s ____ Avg Vel.fps

Sampling Point	Clock Time	Dry Gas Meter Reading CF	Pitot & In.H_2O Δp	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Pump Vacuum in Hg. Gauge	Stack Press In. Hg.	Stack Temp. 1 °F	Probe Box 2 Temp.	Ice Bath 3 Temp.	Filter 4 Temp	Gas Meter Temperature 5 Inlet	Gas Meter Temperature 6 Outlet
B-19(cont)	120		5.8	2.8		9.0		166					
	135	111.834							239	71	242	71	71
A-25	0		6.2	3.0		8.5		167					
	30		5.4	2.6		8.0		166					
	60		5.4	2.6		8.0		163					
	90		5.4	2.6		8.0		167					
	120		5.4	2.6		8.0		169					
	150	117.267							239	71	243	72	71